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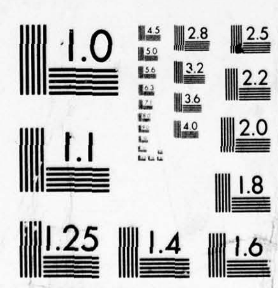

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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DEPARTMENT OF THE ARMY

U.S. ARMY
ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA
CONTRACT NO. DA-44-009-AMC-841(T)

15

PHASE 1

6

ENGINEER DESIGN OF A MONO-MOORING SYSTEM.

9

FINAL REPORT, on Phase 1.

11 1976 12 198p.

J. RAY McDERMOTT & CO., INC.
Engineers and General Contractors
New Orleans, Louisiana

Rec'd 11 August 67

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SECTION I

I. DESCRIPTION OF THE WORK

1.0 BACKGROUND

On October 29, 1964, J. Ray McDermott & Co., Inc. was awarded a contract with the U. S. Army Engineer Research and Development Laboratories for the design of a single-buoy offshore tanker unloading terminal, henceforth referred to as a "Mono-Mooring System". The Mono-Mooring System may be described as an offshore terminal capable of mooring a tanker by its bow, receiving liquid products discharged from the tanker, and providing a passageway for these products to a submarine pipeline leading to an onshore storage facility.

The Mono-Mooring System consists of the following major components:

A surface loading buoy having a rotatable mooring point and a swivel, enabling a surface floating hose to tether about the buoy in any direction;

An anchor system fixing the buoy to the sea bottom;

Tanker mooring lines connecting the bow of the tanker to the rotatable mooring point on the buoy;

A floating hose connecting the tanker manifold to the swivel connection on the buoy; and

A submarine hose connecting the swivel on the buoy to the submarine pipeline.

I. DESCRIPTION OF THE WORK - Continued

1.1 BASIS FOR SELECTION

Although mono-mooring systems which had been providing satisfactory service for a period of approximately three (3) years, were available commercially, investigation by the Army proved that these existing systems did not meet the specialized and highly versatile requirements of a military system capable of providing logistic support under exposed open sea conditions. J. Ray McDermott & Co., Inc., as the Contractor, was therefore, charged with the responsibility of developing a highly advanced Mono-Mooring System which could meet the requirements of the varied criteria established by the Army.

The prime objectives posed by the Army were to provide a system which could:

1. Rapidly unload super tankers,
2. Be installed in almost any part of the world over a wide range of water depths and bottom compositions in the shortest possible time, using the barest minimum of equipment and manpower, and
3. Provide reduced operational capability even when damaged by small arms fire.

A feasibility study had earlier been conducted for the Army by Aerojet General Corporation to investigate

I. DESCRIPTION OF THE WORK

1.1 BASIS FOR SELECTION - Continued

the capabilities and limitations of existing systems and to set forth guidelines for the development of a system which would be compatable with the particular requirements of the Army. This study, together with information gathered by ERDL personnel, in interviews with various companies which were actually operating mono-mooring systems, formed the basis of the ERDL specification which is a part of this contract. It also supplied the background for mono-mooring systems as they existed prior to the time of the award of the contract.

Further, one of the most valuable contributions to the overall development of the Mono-Mooring System designed by McDermott, was made by Shell Oil Company, who, in response to a solicitation by ERDL, pledged their assistance to McDermott and agreed to contribute technical data and experience which had been gained over several years in the development of their own single-point mooring systems. This information, especially the prior knowledge of many of the operational problems associated with mono-mooring systems in general, enabled McDermott to proceed with its design in a systematic manner, avoiding many design "blind alleys" associated with a development effort of this type.

I. DESCRIPTION OF THE WORK - Continued

1.2 OBJECTIVES

The overall objective of this contract was to provide the Army with a design for an offshore tanker terminal capable of accepting petroleum products at an extremely high rate of speed, which could be installed in remote areas of the world in an extremely short period of time.

To accomplish this overall objective, several more specific objectives had first to be attained. These specific objectives are listed below:

1. An extremely high unloading rate.
2. A multi-product system capable of handling a variety of different types of petroleum products without one product contaminating the other.
3. A system capable of reducing the normal tanker turnaround time.
4. A three (3) year service life without major repairs.
5. Minimum installation time in sea-state 2, with personnel and equipment of an Engineer Port Construction Company augmented by special equipment and additional personnel where required.
6. Sustaining operations in a 10-foot sea and a 40-knot wind.

I. DESCRIPTION OF THE WORK

1.2 OBJECTIVES - Continued

7. Installation and operation in varying water depths, ranging from 60 to 150 feet.

8. A self-supporting structure to take care of the required functions for sustaining operations over a long period of time without requiring assistance from heavy construction equipment for adjustment or servicing.

9. Transportation from a forward staging area aboard an LST, freighter, or barges, and launching at the intended installation site.

The first three items could probably have been satisfied by mono-mooring systems which were commercially available at that time. However, it was felt that the ramaining objectives could not be met by existing systems, and would require the additional development work called for under this contract.

Although other requirements were specified by ERDL, it was felt that the above listed characteristics were the most important and would be the most difficult to attain in the mono-mooring system which the Army required. A complete description of the actual design requirements in contained in paragraphs 3 and 4 of the ERDL Purchase Description for Mono-Mooring System, dated February 20, 1964, and included at the end of this section as Appendix I-A.

I. DESCRIPTION OF THE WORK - Continued

1.3 PROJECT ORGANIZATION AND SCHEDULING

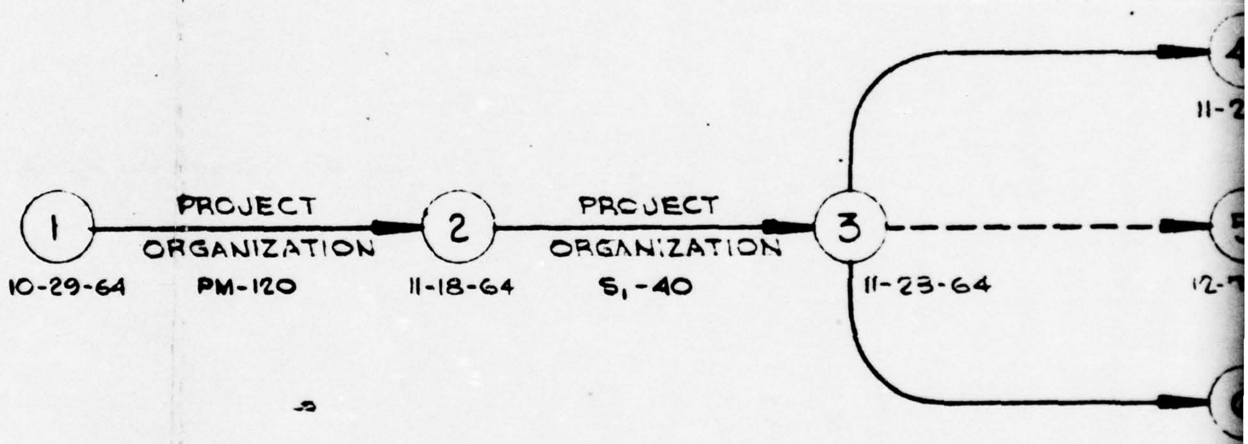
Upon award of the contract to McDermott, the project was organized and a primary work schedule was established so that the required amount of work might be accomplished with the least expenditure of man-hours and within the time limit established by provisions of the contract.

It was recognized at that time that detailed design criteria should be established at the earliest possible date in order that the maximum amount of effort could be expended during the development and design phases of the project. To accomplish this, a detailed schedule of work was prepared. This schedule is included in this section in the form of a "Work Flow Chart", and shows four (4) basic phases of work.

The first phase, covering the gathering of data related to mono-mooring systems, included discussions with various people who had acquired considerable experience in the development of mono-mooring systems, primarily Shell Oil Company. Since the hose is generally considered one of the most critical components of the system, this area of work also included talks with people knowledgeable of large-diameter hose used on previous mono-mooring systems.

The primary objective during the data gathering phase was to separate those components of the system

PM - PROJECT MANAGER
S_1 - DESIGN ENGINEER STRUCTURAL A
S_2 - DESIGN ENGINEER STRUCTURAL B
M_1 - DESIGN ENGINEER MECHANICAL A
M_2 - DESIGN ENGINEER MECHANICAL B
E - DESIGN ENGINEER ELECTRICAL B
C - DESIGN ENGINEER CHEMICAL B
NA - NAVAL ARCHITECT
D - DRAFTSMAN



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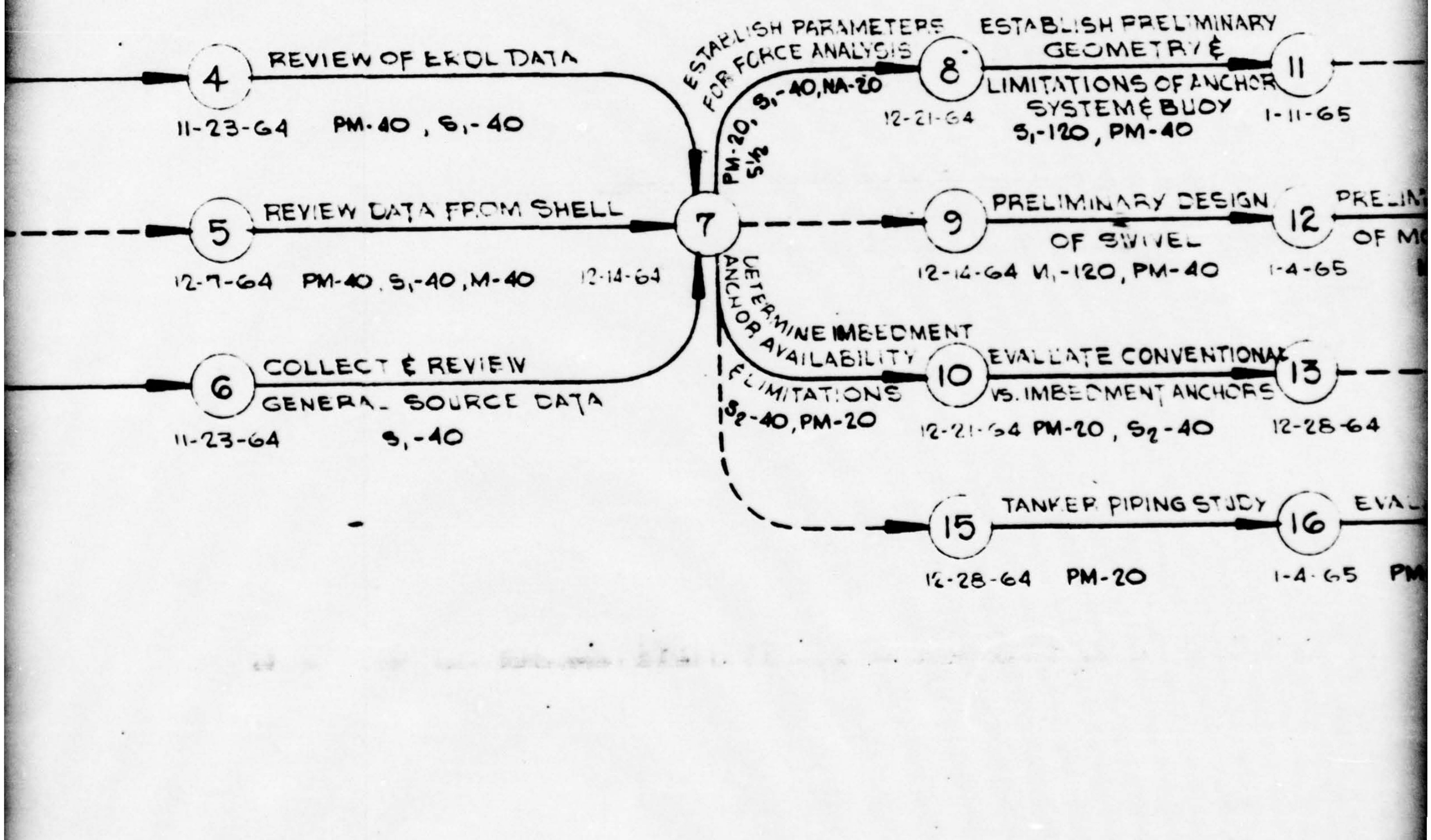

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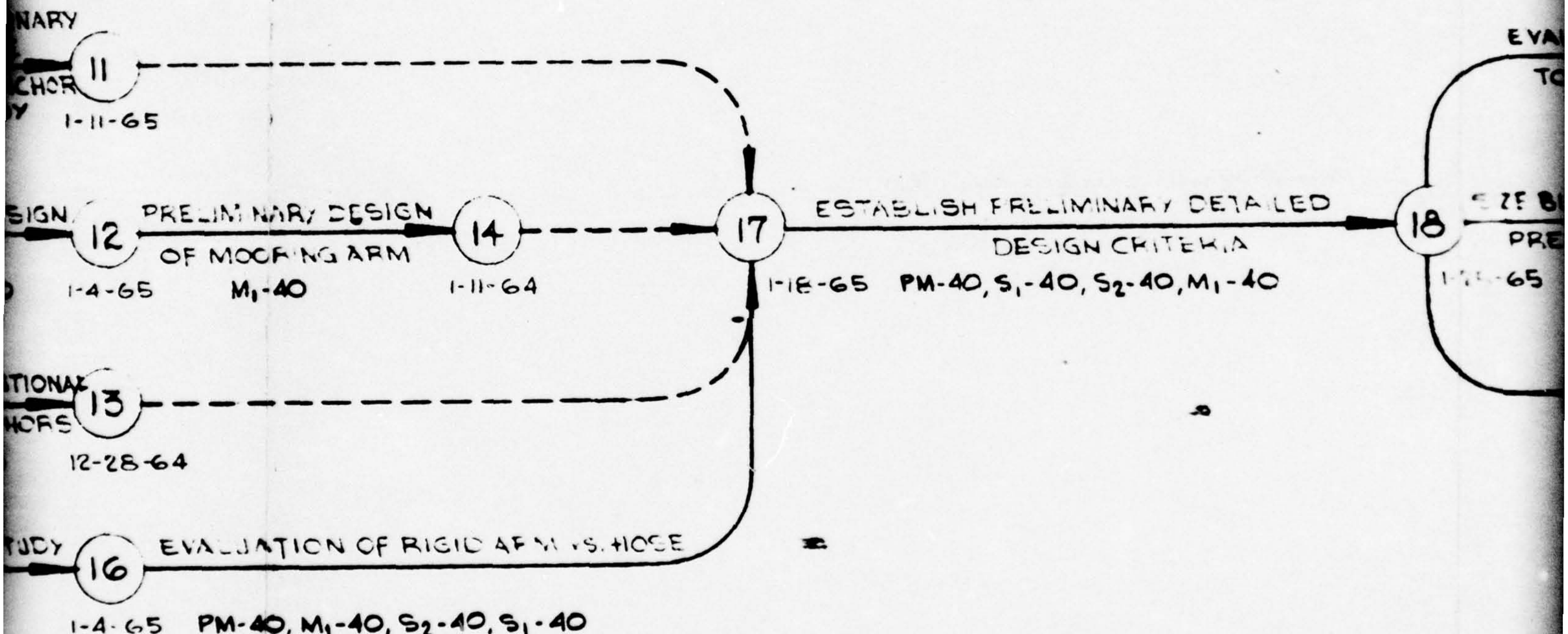

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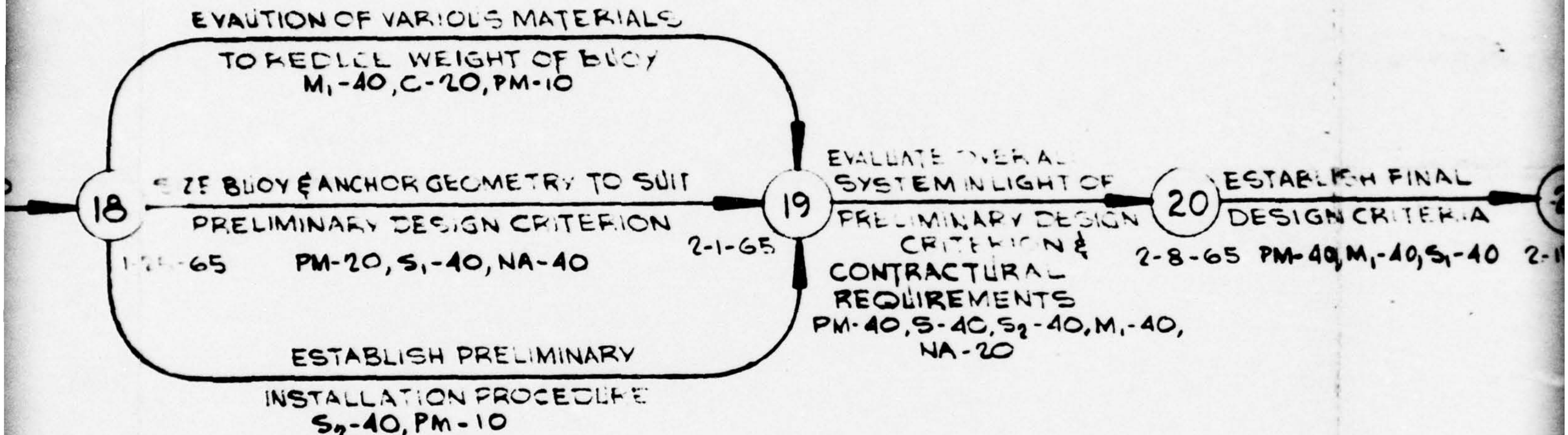
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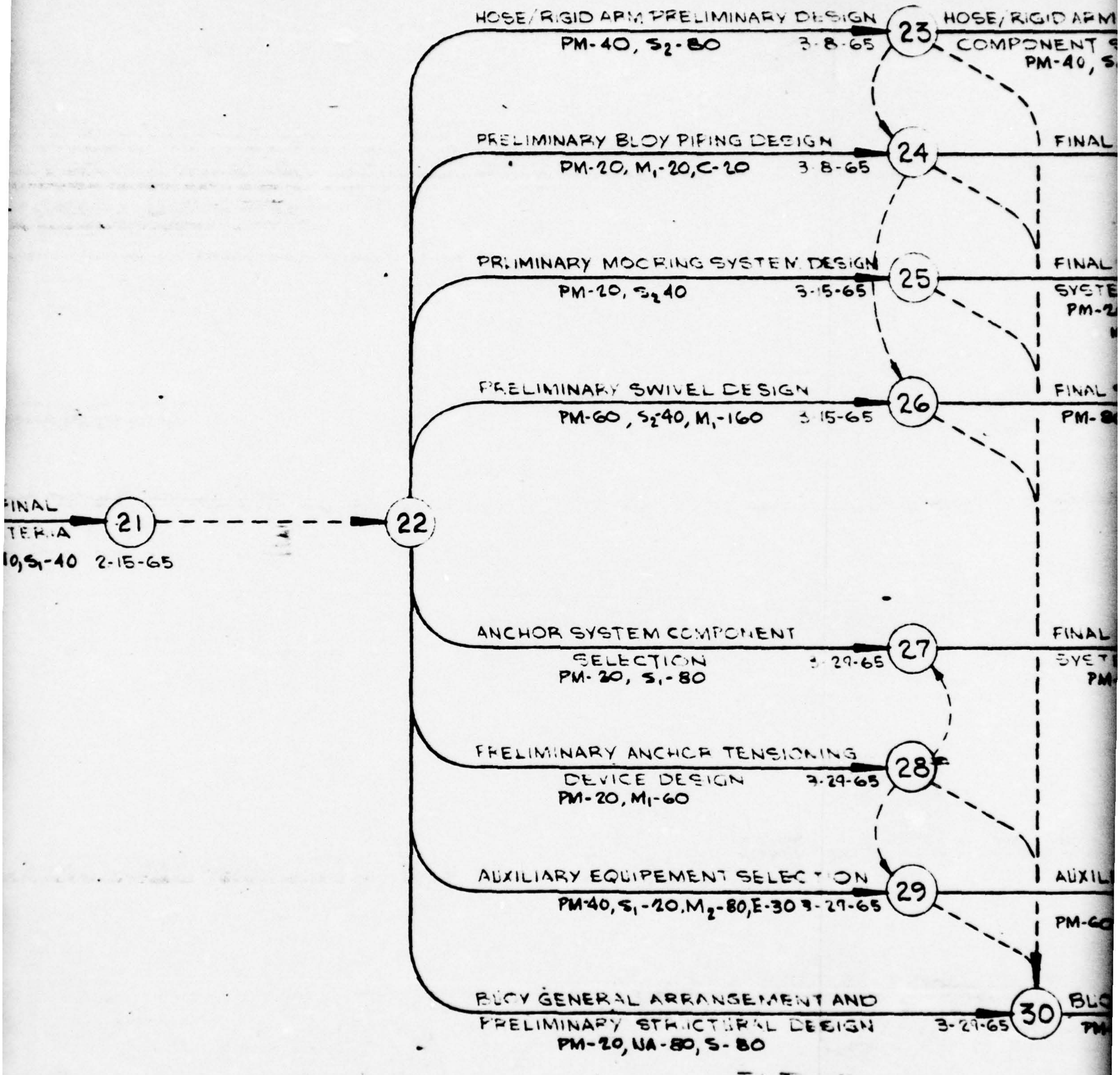
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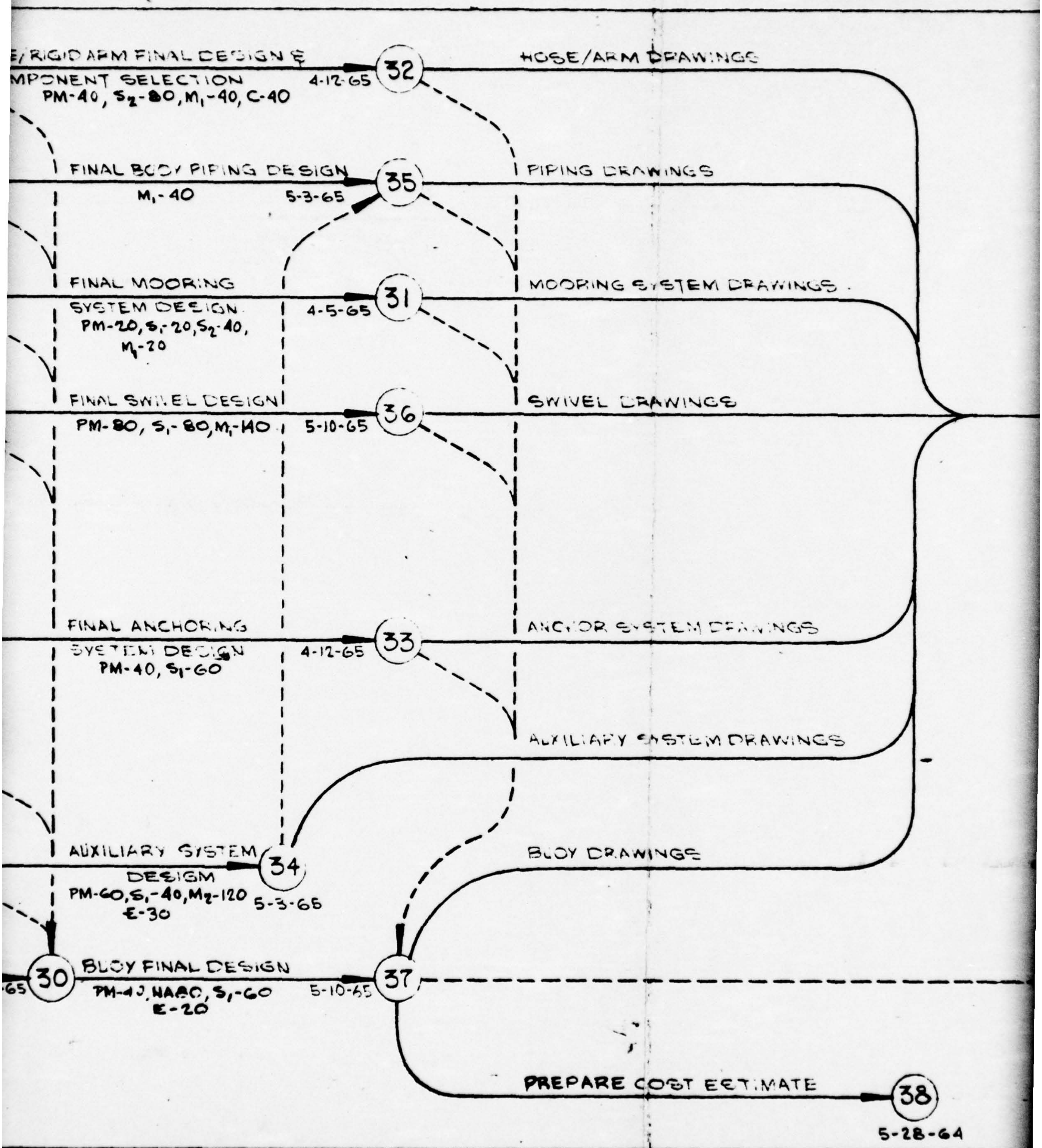
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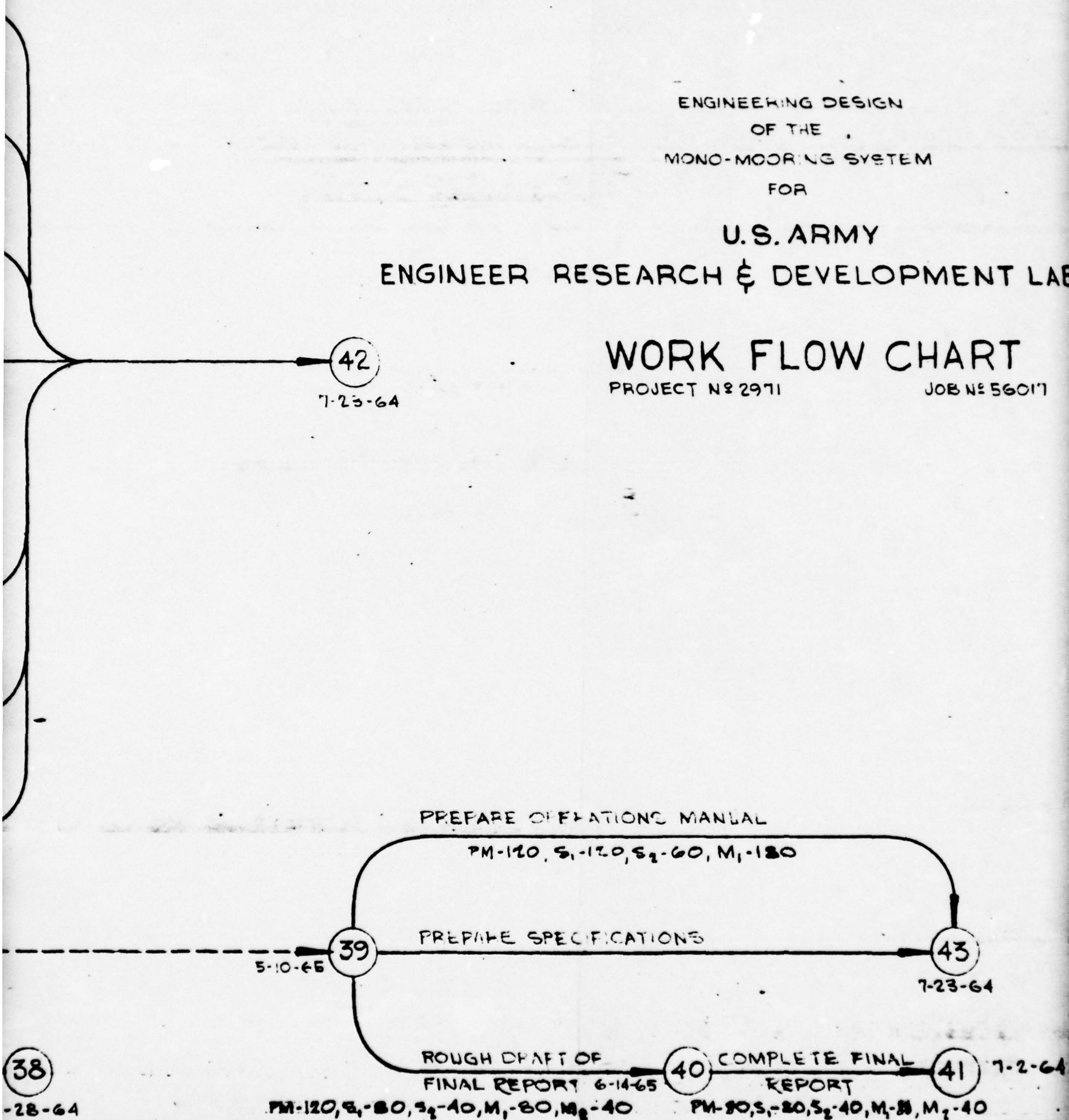
7

ENGINEERING DESIGN
OF THE
MONO-MOORING SYSTEM
FOR
U.S. ARMY
ENGINEER RESEARCH & DEVELOPMENT LAB

WORK FLOW CHART

PROJECT Nº 2971 JOB Nº 56017



ESIGN

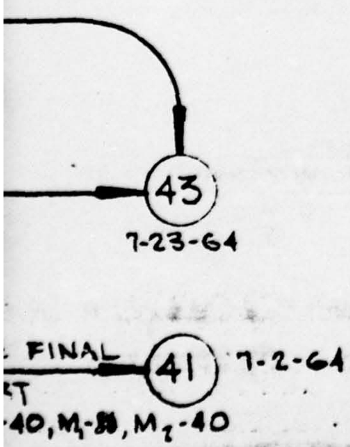
SYSTEM

MY

ELOPMENT LABORATORIES

W CHART

JOB Nº 56017



I. DESCRIPTION OF THE WORK

1.3 PROJECT ORGANIZATION AND SCHEDULING - Continued

which had been developed to the extent that they were now considered reliable, from those components which were considered unreliable or needed further development. Additionally, it was desirable to determine and solve various operational problems and inherent weaknesses of the overall system, the feeling being that recognition of the limitations of existing mono-mooring systems would provide an early indication of those areas where the greatest effort should be directed.

During this phase, design parameters were developed to permit analysis of various types of anchor systems, and a preliminary indication of the geometric configuration required of the buoy.

Prior to award to the contract, ERDL had established that, for a military system, the floating hose connecting the buoy with the tanker was the major component having a history of poor reliability in actual operation. It was considered essential to develop another method of connecting the tanker to the buoy. Several approaches were considered as a means of altering this connection, and the most promising appeared to be a type of rigid-arm connection which would provide both the mechanical mooring connection between the tanker and the buoy, and contain the flow lines necessary to handle the product.

Although not a part of this contract, McDermott

1.3 PROJECT ORGANIZATION AND SCHEDULING - Continued

agreed to conduct a brief feasibility study on a buoy-to-tanker rigid connection, in the hope of determining whether or not a practical connection could be developed within the scope of the contract, or whether it would be more desirable to improve on existing mooring connections and floating hose.

The second basic phase of work was directed towards developing a preliminary system, and evaluating the system so that design parameters and detailed design criteria could be established which were both feasible and would satisfy the military requirements of the Army.

The third basic phase of work covered the detailed design of the overall system, the preparation of final fabrication drawings, and a preliminary cost estimate of the system developed.

The fourth basic phase was the preparation of specifications and other documents required for the final report.

After the work schedule was completed, man-power requirements were evaluated in terms of various specialties required to develop the different components of the system, and personnel having both experience and training pertaining to these components were assigned to the different areas of work. Initially, a project

1.3 PROJECT ORGANIZATION AND SCHEDULING - Continued

manager, with the overall responsibility for the project, one structural design engineer, with the responsibility for the design of the anchor system, buoy structure, and mooring system, and one mechanical engineer, responsible for the various mechanical systems and components on the buoy, were assigned to the project. During later phases of the project, a naval architect, an additional structural design engineer, an additional mechanical engineer, an electrical engineer and a process engineer were assigned, as required.

1.4 DATA REVIEW

After the project was organized, all available data concerning mono-mooring systems, multi-buoy systems, tankers, submarine pipelines, large-diameter hose, anchors, anchor chains, and other related technical data was acculatated and reviewed. Much data was contributed by ERDL at the beginning of the study and was extremely valuable to McDermott in gaining a broad foundation of knowledge applicable to mono-mooring systems. The material reviewed is listed in part in the Bibliography included herewith as Appendix I-B.

During the review of this data, it became apparent that although there was a wealth of technical information available covering various components of the system, there was relatively little available informa-

1.4 DATA REVIEW - Continued

tion concerning the operational problems encountered with mono-mooring systems. At that time, one company, B.I.P.M. (Royal Dutch Shell) had more operating experience with mono-mooring systems than had all other companies combined. ERDL solicited Shell's cooperation, and obtained from them an informal agreement to transmit to McDermott whatever technical information they had available.

McDermott sent it's Project Manager to The Hague to consult with Shell personnel, and a full report on their discussions is included in Appendix I-C.

1.5 ESTABLISHMENT OF PRELIMINARY DESIGN PARAMETERS

Parameters were selected which would permit a detailed force analysis of the combined anchor system and buoy.

Equations were developed, based on buoy deflection from its no-load position, which would yield quantative results of the following terms:

1. Mooring loads
2. Buoy size and configuration
3. Buoy heel angle
4. Load in each anchor leg
5. Required length and size of anchor legs
6. Forces acting on the anchors

I. DESCRIPTION OF THE WORK

1.5 ESTABLISHMENT OF PRELIMINARY DESIGN PARAMETERS - Continued

7. Required amount of pre-load

Due to the multiplicity of variables and the iterative nature of catenary solutions, the abovementioned equations were programmed for computer analysis.

This parametric study, when fully developed, enabled the buoy to be sized approximately, and its shape to be determined.

The first computer runs were made on the basis of wire rope anchor legs and explosive embedment anchors, it being recognized that if the embedment anchors and wire rope proved compatable with the buoy as an anchor system, the installation time would be greatly reduced and the overall logistic operation simplified.

Unfortunately, due to the extremely light weight of wire rope anchor legs as compared to chain, this method did not provide enough deflection of the buoy when acted upon by the tanker. A minimal amount of deflection over the range of mooring loads exerted upon the buoy by the tanker is required in order to absorb the large quantity of energy generated by a moving tanker.

During this same period, a preliminary design of the swivel was initiated. It was anticipated that the design of the swivel would be highly complex, and would require more development time than any of the other components.

I. DESCRIPTION OF THE WORK - Continued

1.6 EVALUATION OF RIGID-ARM DESIGN

As a result of ERDL's research on existing mono-mooring systems and contacts with users of existing systems, it was recognized early that the weakest link was, as previously stated, the floating hose which had repeatedly caused damage to both itself and the buoy during rough weather or when kinked by the tanker over-riding the buoy.

Therefore, immediately after the award of the contract, McDermott was requested by ERDL to include in the scope of the work a brief investigation into the feasibility of another means of connecting the ship to the buoy.

McDermott agreed to investigate several approaches, some of which were suggested by ERDL, at no increase in contract cost. The extent of this brief feasibility study was limited, but broad. The intent was for McDermott to investigate and do a preliminary development on several approaches to the problem in an attempt to determine if the approach appeared to be practical enough to warrant further development.

One approach, the rigid-arm design, appeared to show enough promise that a deemphasis was placed on the development of the conventional mono-mooring system, and additional effort was devoted toward the development of the rigid-arm design.

1.6 EVALUATION OF RIGID-ARM DESIGN - Continued

Several approaches to the rigid-arm design were investigated and evaluated in detail, including for each approach the object of the design, the anticipated design limitations, the possible approaches, and a detailed method of evaluation.

After McDermott had completed its evaluation of the various rigid-arm designs, the matter was reviewed in detail with the Army, and it was concluded by both parties to the contract, that all approaches investigated either proved unfeasible for one or more reasons, or were complicated enough that the level of effort required to develop the system was beyond the scope of this contract.

1.7 PRELIMINARY DESIGN CRITERIA

The process by which designs are evolved, is approximately as follows:

1. Definition of characteristics of the end product
2. Development of a trial design whose basic properties are sufficient to demonstrate that it will or will not provide the characteristics established.

However, in the development of the Mono-Mooring System, the basic concept and type of configuration were

I. DESCRIPTION OF THE WORK

1.7 PRELIMINARY DESIGN CRITERIA - Continued

fairly well defined, and the sizing of the various components and selection of the buoy configuration depended upon the design factors established, and an accurate determination of the forces working on the overall system.

Preliminary design criteria were developed in accordance with specifications contained in the ERDL Purchase Description.

Using this preliminary criteria, a preliminary design of the buoy and anchor system was developed, and the design evaluated against the criteria to insure that all contractual requirements were being met. Concurrently, a preliminary installation procedure was established. This procedure outlined proposed future work in this area, and also provided an indication of how reasonable the Army's requirements on installation were. At the same time, various materials were investigated in an attempt to reduce the weight of the buoy, the theory being that if the buoy could be fabricated of lighter materials, it could be made smaller and could be transported more easily. It was later concluded that, in view of cost considerations, the strength required of the buoy,and the corrosion problem of the lighter metals eliminated all materials except steel.

When the preliminary design of the buoy and anchor system had been completed, the design was evaluated in

I. DESCRIPTION OF THE WORK

1.7 PRELIMINARY DESIGN CRITERIA - Continued

terms of the preliminary design criteria, and those areas of the specification which would be impractical to meet were listed. A meeting with ERDL personnel was held, and out of this meeting a final design criteria was established embodying most of the requirements listed in the original preliminary design criteria.

Detailed design criteria is contained in Item 3 of the Purchase Description, Appendix I-A. P.D.

1.8 PRELIMINARY DESIGN

After the design criteria had been accepted by the Army and the contract changed by Modification No. 1 to reflect the changes in the preliminary design of all the various components of the system, there were eight (8) major areas of design, which are listed below:

1. Hose design
2. Preliminary piping design
3. Preliminary mooring system design
4. Preliminary swivel design
5. Anchor system component selection
6. Preliminary anchor tensioning design
7. Auxiliary equipment selection
8. Buoy general arrangement and preliminary structural design

I. DESCRIPTION OF THE WORK

1.8 PRELIMINARY DESIGN - Continued

During this phase, several alternate approaches were tried, especially in the mechanical areas. As was recognized at the beginning of the study, the swivel design was probably the most complex, and several alternates were studied before an acceptable design was arrived at. In the same manner, the anchor tensioning device went through several stages of development. The first was patterned somewhat after the Shell approach, that of using ball-and-socket chain stopper. However, in order to be able to satisfy the installation time requirement, it was felt that this design must be streamlined, and the result was that a pawl, or ratchet-type stopper, was developed which would enable passage of the anchor chain in one direction only. The pawl-and-socket approach was later discarded in favor of a trunion-mounted stopper.

The structural design of the buoy hull proved to be straightforward, but required a great deal of change because of our attempt to lighten the structure and develop strength adequate to provide a structure which would not be too difficult to fabricate. By this time, it was realized that the most economical approach to anchor selection would be to use either an LWT anchor or a Bureau of Yards and Docks STATO ANCHOR. It was felt that these anchors could be used satisfactorily

1.8 PRELIMINARY DESIGN - Continued

in almost any bottom situation which might be encountered. The explosive embedment anchor, although possessing many advantages, was discarded because it could not be used in all types of bottom which might be encountered, and because two (2) anchors would be required for each anchor leg.

Calculations, sketches, and other design data prepared during this phase of the work, are contained in Appendix "A" to this report.

1.9 FINAL BUOY DESIGN

After acceptable components and sub-systems were developed during the preliminary design phase, these designs were defined and developed further to the extent that the general arrangement and design of the buoy could be finalized and fabrication drawings produced.

1.10 COST ESTIMATE

As soon as designs were finalized, a cost estimate was prepared to cover the fabrication and purchase of all components, and was submitted to ERDL. The Cost Estimate is contained in Appendix I-D.

1.11 ADDITIONAL REPORTS REQUIRED UNDER THE CONTRACT

In connection with and as part of the contract, McDermott is required to furnish the following:

1.11 ADDITIONAL REPORTS REQUIRED UNDER THE CONTRACT - Continued

A. Three (3) copies of a Final Report to include, but not be limited to, the following:

(1) Explanation or basis for selection and/or design calculations for all elements or components of the Mono-Mooring System.

(2) Packaging, Packing, Shipping and Assembly Instructions for the Mono-Mooring System.

(3) Installation Procedure(s) for Installation of the Mono-Mooring System. The procedure(s) should be established based on a study of the personnel and equipment in an Engineer Port Construction Company, which will be the installing unit. (Table of Organization and Equipment 5-129E).

(4) Recommended additional personnel and equipment required to install the Mono-Mooring not contained in TO&E 5-129E.

(5) Operational procedure(s) to bring the tanker into the mooring and connect mooring hawsers, to raise and connect unloading hoses, to disconnect hoses and mooring howsers and to return the tanker to sea.

(6) Preliminary plan of Engineer Design Test of all elements in the Mono-Mooring System sufficient to show if the system and components

1.11 ADDITIONAL REPORTS REQUIRED UNDER THE CONTRACT - Continued

thereof meet the operational requirements of Exhibit "B".

(7) Detailed cost estimate for complete fabrication of the Mono-Mooring System.

(8) Evaluation of the semi-rigid arm designs investigated vs the floating hose system, and selection of one of the three choices listed in paragraph 2b. of Amendment No. 3 to Purchase Description for Mono-Mooring System (Exhibit "B").

B. Three (3) copies of a maintenance and inspection manual for all elements of the Mono-Mooring System.

C. Three (3) copies of a Parts List for all items of the Mono-Mooring System. Components and assemblies should be cross-referenced with drawings and specifications.

D. Three (3) copies of all specifications prepared.

E. Three (3) copies of all engineer and other drawings prepared.

1.12 DEFINITIONS

A-frame	A lifting device installed on the Mono-Mooring buoy and A-frame barge; used to facilitate installation procedure.
A-frame barge	Barge with A-frame, anchor racks and winches, used during installation.
Aids to navigation	Package installed on rotating deck, consisting of navigation lights, fog horn, radar

1.12 DEFINITIONS - Continued

	reflector, and associated power source.
Anchor legs	Consist of anchor and 3" diameter high-strength flash-welded stud link anchor chain extending from anchor at sea bed to chain stopper in buoy skirt.
Anchors	Either STATO or explosive embedment anchors used to secure buoy in proper location.
Anodes	Aluminum alloy anodes attached to buoy hull to provide cathodic protection.
Buoy	Cylindrically-shaped buoy with rotating deck and various components forming a part of the Mono-Mooring System.
Chain stopper	Device mounted in buoy skirt, used to tension and hold anchor leg.
Chain storage boxes	Boxes as illustrated in Drawing No. USA-2971, Sheets 907 and 909-911, used to facilitate transporting and handling of chain.
Chain transfer boom	Trussed trough, with hydraulically-operated wildcat to span from the transportation vessel to the winch barge, thereby facilitating the transfer of the anchor chain. See Drawing No. USA-2971, Sheets 912-916.
Deck-locking device	Device for locking rotating deck of buoy in proper position, as shown on Drawing No. USA-2971, Sheet 813.

I. <u>DESCRIPTION OF THE WORK</u>

1.12 <u>DEFINITIONS - Continued</u>

Dry cargo vessel	Cargo ship or freighter meeting requirements listed in Section 3.1.1 of Installation Procedures.
Floating hose	Hose with floats attached extending from outboard flange of buoy product piping to tanker manifold during cargo transfer.
Floats	Cylindrically-shaped floats which provide necessary buoyancy for floating hose and facilitate proper configuration for submarine hose.
Installation site	Location where Mono-Mooring System is to be installed.
LCM	Sixty-nine (69') foot diesel-powered landing craft, as listed in Document TOE 5-119E, "Table of Organization and Equipment for Full Strength Engineering Port Construction Company".
LST	Military vessel which may be used to transport Mono-Mooring System.
Marker buoy	Buoy as shown in Figure 8 of Installation Procedure, used to mark location of chain ends, anchors and submarine pipeline terminal junction.
Mono-mooring system	Semi-rigid tanker mooring facility for transferring liquid cargo from ship to shore.
Mooring system	Mooring lines and fittings from pad-eye on buoy to mooring bitts on tanker, as illustrated on Drawing No. USA-2971, Sheets 827 and 828.

1.12 DEFINITIONS - Continued

Overboard swivel	Swivel joints located on buoy product piping just above floating hose flange connection. Used to position hose to suitable departure angle.
Staging area	Area near installation site used for receiving and loading out various components of mono-mooring system for transfer to installation site.
Storage area	Area remote from installation site having facilities for storage of all components of the mono-mooring system.
Submarine hose	Hose extending from pipe flanges in the interior well of the buoy to the submarine pipeline terminal junction on the sea bed.
Submarine pipeline terminal junction	End of underwater pipeline laid on the sea bed, from shore to mono-mooring system.
Swivel	Product-handling swivel located in inner well of buoy, and capable of turning with rotating deck.
Senhouse slip-hook	Quick-release mechanism to be used in mooring system.
STATO anchor	Fabricated steel anchor, as specified on Yards and Docks Drawings Nos. 813503 through 813506.
Tag buoys	Spherical PVC buoys forming a part of the mooring system.

I. DESCRIPTION OF THE WORK

1.12 DEFINITIONS - Continued

Tug	Medium-sized tugboat meeting requirements specified in Section 3.1.2.1, Item 8, of the Installation Procedure.
Warping tug kit	Apparatus to be installed on LCM, to facilitate the assembly of the floating and submarine hoses.
Skid-mounted windlass	Skid-mounted machinery consisting of a hydraulically-powered wildcat used during installation of the anchor legs.

1.13 APPENDICES AND REFERENCES

Appendix I-A	Purchase Description
Appendix I-B	Bibliography
Appendix I-C	Trip Report
Appendix I-D	Cost Estimate

Purchase Description for Design removed and put in MERDC Final Report, 30 June 69 Hm

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FILE D-4

TRIP REPORT

JANUARY 10, THRU JANUARY 20, 1965

The following report covers the trip to The Hague and London by C. R. Bell and G. R. Smith and the trip to Fiumicino, Italy by G. R. Smith for the purpose of gathering technical data from different people who have been intimately associated with Mono-Mooring Systems during the past three years.

Date: January 12 and 13, 1965

Location: Shell's Offices in The Hague

Subject Discussed: Mono-Mooring Systems in General

Personnel in Attendance:		
	Mr. John Coombe	Shell
	Mr. J. H. Dryson	Shell
	Mr. C. R. Bell	McDermott
	Mr. G. R. Smith	McDermott

It was decided in view of the large amount of material to be covered that the Mono-Mooring System would be covered by components in the following order:

1. Anchor System
2. Swivel
3. Turntable
4. Hose

Anchor Chain

The size of chain Shell has been using is $2\frac{1}{2}$" from the upper part of the chain and 3" for the lower part with 2-9/16 sometimes used in between. Mr. Coombe feels that 3" chain could be used throughout with possible better results. The type of chain they are using is high tensile steel stud link flash welded chain. The method Shell uses in sizing their chain is to consider the proof load of the high strength steel equal to the breaking strength of mild steel. Then they size the chain so that when they have a maximum load this equals 35% of the breaking strength of the chain. Mr. Coombe feels that the expected life of 3" chain is approximately three years. They have had no breaks or chain breakages except at Nigato and he feels that this was due to having a loose chain. Shell has not used any di-lok because they believe that the corrosion fatigue which is possible in di-lok would cause failure.

We asked if they had experienced a large amount of wear in any particular part of the chain. Mr. Coombe indicated that the first one or two links next to the buoy which tend to rub against the hawse pipe seem to show the most wear. He also explained that when the chain is first installed the rate of wear is more rapid than during its later life. This is due to the fact that the bearing area of one link working on another is smaller in the beginning but as the chains wear this area or surface is increased. He also stated that the length of chain which tends to raise off the bottom and then contact it again is an area where a higher rate of wear is experienced.

We then asked Mr. Coombe what amount of pre-load was used on the Shell buoy. He said that the initial tension will vary directly with water depth. He also indicated that we should change a co-efficient which was stated as 2.613 in his notes on the Nigata buoy to 1.847. He said that in 80' of water depth, their pre-load is approximately 5 Tons. He said that the chain length used is based on static horizontal pull of 120 Tons. The catenary is calculated so that the chain will become tangent with the bottom before connecting to the anchor. He agreed that a possible increase in initial tension might be beneficial but warned that this would mean that the buoy displacement would be greater. When asked if they had investigated the dynamic reactions between the buoy and the tanker he said that Shell determines the relationships by model tests and that their actual experiences with full size tankers and buoys agree fairly closely with these tests. He said Shell uses 12" circumference nylon mooring lines and that larger ships require longer mooring lines. We asked why Shell used anchor chain over the bow of the ship. He said due to the Nigata test where wire rope was used in way of the fairleads or chocks in the bow of the ship that they had failed but in his opinion this was not conclusive due to the poor configuration of the chocks on the particular ship used. When asked what size anchors were used, he said that at Qatar 16 kip Danforths were used and four legs used single anchors and four legs used double anchors. The double anchors were used in the prevailing storm direction. At Fort Dixon stockless anchors were intended; they did not work and British admiralty pick anchors were actually used. He said that the Danforths can be set when drug 15' and that later tensioning is required after the anchor has been attached to the buoy. He did not like clumps behind the buoy and he did not like sinkers. When asked why he did not like sinkers he said that Shell did not have much experience with sinkers. He said that a 16 kip Danforth can hold about 70 Tons of horizontal pull.

Retensioning Anchor Legs

Mr. Coombe said that a derrick barge is used initially to tension the anchor legs and that, using the Shell method for later tensioning, approximately 5 to 6 hours are required for a three foot take-up. The excess chain is burned off and allowed to fall to the bottom. He felt

that the retensioning time could be reduced to about 4 hours in a military operation. Shell uses an air motor winch to retension their anchor legs. When asked what sea state or what wave height was considered maximum for a Shell installation he said that about 2' was maximum. The rotation of the deck during tensioning is done by having a small boat pull at the periphery of the deck. No locking devices are used by Shell. The capacity of the buoy derrick is 15 Tons. He cautioned that if the excess chain were left on the buoy this will have an effect on trim. This is not good because it makes the rotating deck work up hill part of the time. Also the stability of the buoy is considerably increased after the chain has been attached.

Mr. Coombe was asked what a reasonable value of buoy trim under full load is. He said that the most trim experience by Shell was with the Nigata buoy and that this was not a very good example, because of the lack of initial tensioning in the legs, but that in the Nigata buoy they experienced approximately 15^{o} trim.

Swivels

The pressure drop Shell has experienced from the ship to the sea-line is approximately 50 psi and this is based on a particular installation flowing at approximately 40,000 BPH. When the flow rate is dropped to 20,000 BPH on this installation the pressure loss drops to 20 psi. The pressure drop through the swivel is estimated at about 10 psi. The best method for estimating pressure drop through hose, and this is used by Shell, is 1.33 or 1-1/3 times the equivalent smooth pipe pressure drop. Mr. Coombe was asked what type of packing gland they use in their swivel and it is a J. Walker solosele univoil 80/GHN/CC. They use expansion joints from the swivel to the manifold made by U. S. Rubber. This expansion joint is rated at 800 psi burst and is factory tested to 200 psi. It is of the double arch type. The swivel is pinned to the turntable. The turntable rotates the swivel.

Turntable

Mr. Coombe felt that a considerable improvement could be made in their turntable and deck layout by starting with the design of the piping on deck and then frame around the piping. This would eliminate much of the dynamic imbalance that is experienced in Shell's swivels.

When asked whether the bogie rails were machined by a large radius boring mill, Mr. Coombe indicated that these rails are rolled then welded to the buoy and any imperfections are eliminated with a hand grinder. We asked Mr. Coombe if he thought any improvement could be made over the existing systems by using an outer race to control vertical loads and deflections and an inner race approximately 10' in diameter to control all horizontal loads. He mentioned that this

had been tried by Shell and was later dropped. But, on second thought, could see no reason why it should not work. We asked what effect, in his opinion, raising the skirt would have on the buoy. He mentioned that this would tend to eliminate the lower flange or the strength derived from the lower flange which is the bottom of the buoy.

Various Existing Problems with SBM Systems and the Approaches Used to Overcome Them

Mr. Coombe enumerated several tests they are conducting at the present time in different model basins throughout Holland to separate the ship and the buoy. He described the problem of the ship passing the buoy or overriding it and the pinching of the hose between the buoy and the ship. Most of Shell's efforts in arriving at a rigid arm seem to contain the weakness of the rigid arm having to withstand the moment induced upon the ship by a change in current or wind, necessitating that the rigid arm have an extremely large section modulus and hence bulk.

Shell feels that one of the greatest improvements that could be made in Mono-Mooring Systems would be to eliminate the tender vessel. The overall mooring operation is limited by the sea-state that the tender vessel is able to operate in. If it could be eliminated, the ship could conceivably moor in a much higher sea-state than is now practiced.

Another area for considerable improvement would be to reduce the length of the hose which would in turn cut the cost of the system, and reduce the pressure drop and vulnerability of the hose. One of their largest hose problems now is the ability of a tanker hose handling gear to lift these heavy hoses from the water.

Mr. Coombe then enumerated at some length the progress made on potential patent applications, and a general description of the work that BP, British Petroleum, has accomplished to date. They have an installation in the Thames Estuary which is quite different from anything that has been done thus far in the way of Mono-Mooring Systems. They have done some rigid arm work and have a patent on a rigid arm. However, as far as we were able to tell, it seems that the problems of the tanker pivoting within the rigid arm had not been solved.

ERDL Questions

1. Why is it desirable to adjust the buoy manifold angle with respect to the mooring point?

   Answer: Mr. Coombe indicated that this is a bit impractical due to the framing of the rotating deck. However, the reasons for having an adjustable manifold angle are as follows:

In severe weather or with a large amount of current, it is desirable to have the angle between the mooring connection and the hoses minimal so that the hose can tether from the buoy without creating a large bending moment in the hose. Here 45^{o} is adequate. In periods of light weather a large angle with a mooring connection is desirable; when the ship rides up on the buoy the large angle would tend to eliminate the pinching of the hose between the ship and the buoy. Mr. Coombe liked the idea of having a swivel right at the mouthhold just above the waterline to accomplish this variation in angle. He also mentioned that Shell's manifolds no longer terminate at the waterline and horizontal to it, but 15^{o} from the waterline in a downward direction, and 1 ft. above the waterline. He mentioned that the flanges in this area should be 300 psi flanges, or stronger.

2. How do they feel about ERDL's requirement for 1/4" of diametral corrosion allowance being allowed for each year in service on the anchor chain?

   Answer: Shell has not had this much corrosion and their 35% design factor is intended to take care of corrosion. This is current British Navy design practice.

3. What is the best type of anchor chain?

   Answer: Flash welded high strength stud link chain. This has been used on all Shell installations.

4. Why is chain used in their mooring lines?

   Answer: To avoid abrasion over the side of the buoy and through the chocks of the ship. Mr. Coombe suggested that a poly-ethelyne or similar plastic cover over wire rope might be equally as successful.

5. What is the amount of turning effort required to rotate the swivel and the rotating deck?

   Answer: Shell specifies 1 Ton at the periphery of the buoy.

6. In Shell's opinion what are the best floating hose types used today and who are the best suppliers?

   Answer: Shell has procured floating hose from both U. S. Rubber and Hewitt Robbins to their specifications which are a 200 psi test pressure rated 800 lbs. burst, an elongation less than 2% under the test pressure. They emphasized that Shell has had approximately equivalent performance from both suppliers because the hose is built to their specifications.

7. What type of couplings have been used to connect the floating hose to the tanker manifold?

   Answer: Shell has used the Camlock couplings.

8. What is the heel angle of the buoy that Shell has experienced and what do they feel should be the maximum allowable heel angle?

   Answer: About 15^{o}.

9. How much horizontal deflection is permissible in a mono-mooring buoy?

   Answer: Shell has experienced about a 20 to 25' horizontal deflection in 80' of water depth with a 120 Ton load.

10. Why is hose adjacent to the buoy left unbanded?

    Answer: Since this hose departs the buoy at some angle relative to the axis of the ship, multiple lines tend to bend at different radii. Leaving them unbanded tends to allow one hose to ride up on the other relieving whatever bending stress would be in the hose. The reason for not banding the hose at the tanker manifold end is to enable the ship to lift one line at a time. Mr. Coombe said that it takes about 2 hours to connect the hose and 1 hour to disconnect the hose.

Date: January 14, 1965

Location: Shell's Offices in The Hague

Subject: Large diameter hose for Mono-Mooring Systems

Personnel in Attendance:		
	Mr. John Coombe	Shell
	Mr. G. H. Sondermeyer	Shell
	Mr. G. R. Smith	McDermott

General

The following notes have been recorded in the order in which various subjects related to hose were discussed.

Mr. Sondermeyer said that the lazy S configuration used for the submarine hose is best and that the length of this hose should be about 2 times the water depth. Their submarine hose is tested to 200 psi with a rated burst of 800 psi. They have experienced no problems with external pressures. However, they have experienced a problem with the PVC floats supplied by US Rubber compressing at the deeper depths of water with the attendant loss in buoyancy.

The manufacturers of the floats used by Shell are: Draka Plastics Limited located in Hilligan, Holland; and La-Sebino-Resine located in Brescia, Italy. Mr. Sondermeyer recommended the Hewitt Robbins buffalo float for the submarine hose.

When asked what type of bolts were used for making up the banding, when connecting more than one hose together, he said that monel is used for the floating hose and ordinary steel bolts for the submarine hose.

He mentioned that the float sink hose to his knowledge has not been very successful. The primary purpose of the floats is for buoyancy and abrasion resistence. Normally, there are 18 to 20 floats per 30' length of hose and these provide 36% extra buoyancy. Their hose specifications call for less than 2% elongation at a test pressure of 200 psi, and a rated burst pressure of 800 psi.

When asked about the possibility of using hose without wire reinforcement he said that rayon or teryolene cord might be used but that in his opinion a soft wall hose would only last six to twelve months. Shell uses a 1 wire hose rather than a double reinforced hose for their deck hose. Mr. Sondermeyer said that if a light weight no-wire hose like H-1515 of U.S. Rubber could be used it would only weigh about 30 lbs. per foot in 12" diameter hose. This looks very interesting but he warned that it will kink. Shell always uses smooth bore hose. He said that U. S. Rubber supplies them with a combined layer of wire cord and helical wire in their H-2828 floating hose and Hewitt Robbins uses 2 solid wire helices with no wire cord. Their designation is 26-6918.

All of the floating hose must be covered with floats for abrasion resistance. The newest expanded PVC floats from Italy can be opened and slipped over the hose directly without the necessity of going over the flange, and then they are glued together with epoxy. He said that they leave their hose unbanded for the last hundred feet of hose alongside the ship and for the first hundred feet going away from the buoy. Shell feels that one connector or band per 30 feet of hose is sufficient.

He mentioned that in tankers up to about 85,000 dead weight tons, the manifolds are usually 12" diameter.

The configuration used by Shell at the ship side is with a butterfly valve, a spool piece then a flange having a lifting lug for raising it up to the side of the ship. Extension hoses are needed to get over the rail to the manifold. These vary in lengths up to approximately 24'. A possible alternate approach would be to bring the floating hose directly over the rail eliminating the elbow. This would require hose saddles. Note: This approach will be discussed further in the conference with U.S. Rubber.

Date: January 15, 1965

Location: U. S. Rubber Overseas Offices in London

Subject: Mono-Mooring Systems in General with Special Emphasis on Mono-Mooring Hose

Personnel in Attendance:		
	Mr. John Black	U. S. Rubber
	Mr. George Bruce	U. S. Rubber
	Mr. C. R. Bell	McDermott
	Mr. G. R. Smith	McDermott

Originally a trip had been planned to visit the British Petroleum buoy in the Thames Estuary. Due to some operational problems with the buoy, Mr. Black was unable to arrange this trip. However he had contacted Captain Calini, the Marine Superintendent of Fina Italiana at Fiumicino, and Captain Calini had said that he could be available the following week if we were interested in visiting the Fiumicino buoy. After calling John Christians at ERDL and getting approval for the trip, it was decided that Roger Smith would accompany Mr. Black to Fiumicino on Tuesday morning to visit the buoy.

Mr. Black gave a rather thorough description of the British Petroleum buoy. It is situated in 50' of water and is moored directly to a slab on the bottom by four vertical chains. The buoy was designed by Mr. Ken Hopkins. The buoy is only experimental and only water will be pumped through it to determine its behavior. Mr. Black did not have a very high opinion of the buoy in general.

Mr. Black gave a run-down on several buoys which are in operation or plan for installation in the near future. Among these were the Fiumicino buoy, the Korean buoy, the Japanese buoy, all of IMODCO's manufacture and the three buoys now operating in Miri, the Fort Dixon buoy and the new buoy about to be installed for Oasis Oil Company in Libya. All of the latter buoys were built by Werf Gusto.

U. S. Rubber's H-2828 floating hose of 12" diameter has recently undergone an extensive test to determine the minimum bending radius and also the force required to bend the hose. It turns out that the minimum bending radius for this hose is 74".

When asked how easily the IMODCO swivel turns, Mr. Black replied that it was extremely difficult to turn and was so noisy that it sounded as though some type of failure was taking place when it is turned.

The problem of separation of cargoes one behind the other was discussed at some length and then the meeting was concluded.

Date: January 18, 1965

Location: The Shell Building in London

Subject: Operational Problems Encountered with SBMs and Their Potential Solution

Personnel in Attendance:		
	Captain J. D. Rendal	Shell
	Captain A. F. Dixon	Shell
	G. R. Smith	McDermott

Comparison of Conventional Moorings with SBMs

Captain Rendal stated that there are now three SBMs in operation in Miri and one has been in operation since 1960. These SBMs have replaced former multiple moorings. The intended purpose of installing the SBMs was to save time in mooring and unloading tankers and also to reduce their labor force. One of these SBMs will pass three products, crude and bunkers. When asked if in his opinion the SBM is successful in saving time and reducing the labor required to service and maintain them, Captain Rendal answered in the affirmative and added that Shell, in general, has been quite satisfied with the SBM as a replacement for multiple moorings. Captain Rendal then went on to describe the two buoys in Yokkaichi, Japan. These are new buoys recently installed. One is in 70 feet of water and will service tankers up to 100,000 DWT in size and the other is in 60 feet water depth and will handle tankers up to 80,000 DWT. Their method of separating products is to use a water plug. If they were pumping crude, when they were finished with the crude they would follow this with a water plug for cleaning the line and then with the next desired product.

Weak Points

When Captain Rendal was asked what in his opinion was the weakest part of the system, he felt that the mooring lines could stand the most improvement. He said that the mooring line and the accessories required to moor the ship are bulky, portable equipment and they must be passed up to the ship and then removed from the ship before departure. Also, he indicated the mooring operation is too lengthy. Ships lines are not used because they do not have the correct elasticity or spring constant. Also advantage in Shell's system is the use of the fewest lines possible which in their case is two lines. The breaking strength of these lines, which are 12" circumference nylon line is 150 long tons. The reason for using anchor chain at either end of the mooring line is to prevent chafing. Captain Rendal felt that possibly Shell's mooring hawsers are too heavy, and, if given enough thought could be considerably lightened. He suggested

that we check what Oasis is planning to use. He thinks they are planning to use a purely synthetic line with no steel hardware. He described the unique type of mooring hawser arrangement used in Qatar and said that the reason for the chain is to provide additional safety because it is permanent mooring. He said that another problem in the SBM is that with changing currents and tides the hose tends to wrap around the buoy. Captain Rendal described the problem of a current change and the hose getting between the buoy and the tanker before the tanker moved. He suggested as the solution a means of preventing the ship from moving toward the buoy or a rigid arm or some stern mooring; or alternately a means of preventing the hose from moving. I suggested that possibly a spring line could be used to tie the hose back, and he thought this was a good idea. He said that the eventual objective in mooring the tanker will be to accomplish this without the use of a tender. This confirmed the opinion that we have heard previously from others.

In describing the maneuverability of a tanker, he said that steerage way can be maintained with 3 to 4 kts. headway and that with this speed it takes 800 to 1200 feet to bring the ship dead in the water. He suggested a possible means of picking up the mooring would be to have a light floating line extending out well past the mooring lines and have the tanker approach it at 90° and snag and pick them up as it passes, or in otherwords the tanker would bypass the buoy and in the process, would pick up the lines.

Hose Connections to Ship Manifold

Captain Rendal suggested that possibly a universal expansion joint which is used in refineries might be used just outboard of the manifold flange. This would allow easy alignment of the flanges. He stated that adequate support is necessary in bringing the lines over the side.

Maintenance Program

Captain Rendal stated that a continuing and systematic maintenance program should be inforced if an SBM is to be remained in operation permanently. He said that the anchor lines frequently need re-tensioning and that a large amount of time should be spent in selecting the type of anchor and suiting it to the bottom conditions at the site. He said that Shell uses a British pick anchor on very hard bottoms and that clump anchors were used in Miri, which I think has a rather mud bottom. He said that they had problems with the anchor chains chafing against the hawse pipe on the buoy. As part of a maintenance and inspection program he suggested the following items be checked: Nylon hawsers, hose, lubrication on the buoy, batteries and the communication facilities.

Date: January 19, 1965

Location: Fiumicino, Italy

Purpose: To discuss operational problems with personnel from Fina Italiana

Personnel in Attendance:		
	Captain Vittorio Calini	Fina Italiana
	Mr. John Black	U. S. Rubber
	Mr. G. R. Smith	McDermott

We were unable to visit the buoy as originally intended due to weather; the waves were approximately 15 feet high at the buoy. This buoy is an IMODCO buoy and has been in use for three years. It is used for the transfer of crude and at present is operating with one 12" floating hose, only. Originally, it operated with two 12" hoses but one was torn off in a storm. The system is able to survive 18' waves with no tanker attached. The swivel seems very difficult to turn, and the effect of current on the hose will not turn the swivel. Fina Italiana's operation there is limited by the sea state which their tender or launch can operate in. This is a 50 to 60' boat.

Hose Damage to Date

They originally had two 12" U. S. Rubber H-2828 floating hoses and three rough bore submarine hoses. The floating hose was carried away in a storm. Failure at the buoy connection of both the floating hose and the submarine hose occured. This failure seems to have occured just behind the nipple. The system was originally designed as a float sink system. The float sink operation was successful for about one month, then it was discontinued. Some of their hose which was stored in a small yard was inspected in detail and it appeared that the hose which had been protected by PVC floats was in almost new condition on the outside. The Fiumicino installation was accomplished with the use of a 60 metric ton A-frame derrick barge and many divers. The first installation was difficult and time consuming, it was very difficult to tension the anchor legs. The method IMODCO uses to tension the anchor legs is that they use a roller at the buoy and the chain goes over the roller and doubles back and is attached onto the chain again. The buoy has a four legged anchor system; they use 3-1/4" chain from the buoy down to an 8 ton sinker and from there on to either a 10 or 15 ton anchor. They use approximately 400 feet of anchor leg in 60 feet of water.

During the installation it was extremely difficult to attach the submarine hose manifold to the buoy. This was done in the water and required six divers, with come-a-longs used on the deck to pull the manifold up. The divers were used to get the manifold into position and bolt it to the buoy.

The majority of the hose problems associated with the Fiumicino buoy seem to stem from the anchors not holding. These were stockless anchors. They have accommodated tankers up to 60,000 DWT in size. Captain Calini emphasized the need for ballasting the tanker as it discharges cargo. He said that this lessens the tendency of the ship to veer back and forth due to shifting or changing wind direction.

COST ESTIMATE

BUOY FOR MONO-MOORING SYSTEM

ITEM		COST
Structural portion of the buoy, the rotating deck, and installation of the buoy equipment:		
Material	$ 56,595	
Labor	111,458	
		$ 168,053
Buoy Equipment		218,705
TOTAL ESTIMATED COST		$ 386,758

This estimate is based on the requirements of Item No. 1.2.a. (7) of Exhibit "A" of the contract and does not include any allowance for taxes, transportation, or testing.

The estimate of $168,053.00 for the structural portion of the buoy, rotating deck and installation of equipment includes the following:

1. The structural portion of the buoy itself, as shown on on Drawing Nos. USA-2971, Sheets 800, 801, 802, 804, 805, 806, and 807.
2. The rotating deck, as shown on Drawing Nos. USA-2971, Sheets 803, 805, 808, 813, and 814.
3. The inner and outer race, as shown on Drawing No. USA-2971, Sheet 809.
4. The ventilation system, as shown on Drawing No. USA-2971, Sheets 810 and 811.

Appendix I-D

5. The A-frame, as shown on Drawing Nos. USA-2971, Sheets 815, 816, and 817.

6. The gut line and the base for the 5-ton winch, as shown on Drawing No. USA-2971, Sheet 812.

7. The foundation for the hydraulic pumping unit, as shown on Drawing No. USA-2971, Sheet 892.

8. The hydraulic and electrical control box, as shown on Drawing Nos. USA-2971, Sheets 893 and 894.

9. The pipe supports for the flow system piping, as shown on Drawing No. USA-2971, Sheet 895.

10. The electrical system, as shown on Drawing Nos. USA-2971, Sheet 601 thru and including Sheet 605.

11. Handling and installation of equipment as listed in the following paragraph.

The estimate of $218,705.00 for buoy equipment includes the following items and systems:

1. A-frame with blocks and rigging.
2. A-frame winch.
3. Hand winch for rotating deck.
4. Bogie wheels.
5. Chain stoppers.
6. Navigation aids and lights.
7. Hydraulic system:
   a. Diesel engine
   b. Engine coupling
   c. Hydraulic pump
   d. Valves, controls and piping
8. Cooling water system.

9. Fuel system.
10. Engine exhaust system.
11. Ventilation system.
12. Bilge system.
13. Lighting system.
14. Power and lighting batteries.
15. Cathodic protection.
16. Product piping.
17. Main swivel.
18. Lifesaving and firefighting equipment.
19. Foam flotation.

The weight of the structural portion of the buoy and the rotating deck is 140 short tons, the weight of the buoy equipment is 41.1 short tons. The total weight of the buoy and installed equipment is 181.1 short tons.

SECTION II

II. PACKAGING, PACKING, SHIPPING, AND STORAGE

2.0 PACKAGING AND PACKING

The buoy and its components, such as anchors, anchor chain and mooring lines, shall be packaged for shipment in accordance with the applicable provisions of Military Specifications MIL-P-10783, "Packaging of Boats, Harbor, and Small Craft (Up to 100' Overall Length) for Overseas Shipment".

2.1 SHIPPING

The component parts of the Mono-Mooring System shall be loaded and shipped in accordance with instructions contained in Section III, "Installation Procedures".

2.2 STORAGE

2.2.1 Buoy

The buoy shall be stored in an area protected from the outside atmosphere. Should it become necessary to store the buoy outside, it shall be placed on blocks well off the ground and completely covered with a waterproof tarpaulin or other suitable material. The chain stoppers shall be removed, coated with Type P-1 preservative, and stored in a dry place. The rotating deck shall be locked in position.

Product piping shall be completely drained and fog-coated with Type P-10 Grade 2 preservative. All valves exposed to the weather shall have operating shafts and stems coated with

II. PACKAGING, PACKING, SHIPPING, AND STORAGE

2.2 STORAGE

2.2.1 Buoy - Continued

Type P-2 preservative. Butterfly valves shall be left in the full-open position; all others shall be tightly closed. Blind flanges with gaskets and bolts shall be installed to blank off all open connections. Any unpainted working surfaces shall be coated with Type P-1 preservative.

All electrical assemblies (control panel, work light, navigational light, etc.) which are removed from the buoy shall be detached and stored in conformance with Military Specification JAN-P-658. All exposed ends of wires, plug openings, sockets, plugs, terminals and openings in junction boxes shall be covered with Type II Grade B pressure-sensitive tape, and then coated with an application of ignition-insulation compound. All batteries shall be stored in a dry, charged condition, in accordance with good commercial practice. The electrolytes shall be stored in U. S. one-gallon bottles, in accordance with Military Specification JAN-P-207. All connections to batteries shall be broken, and the terminals and leads coated with Type P-6 preservative and tagged to indicate polarity.

2.2 STORAGE

2.2.1 Buoy - Continued

All non-removable mechanical equipment installed on the rotating deck or in the buoy shall have all working parts coated with an approved preservative.

Enclosed gear housings, grease fittings, etc. shall be drained of accumulated water and filled with operating lubricants. The rotating deck shall be kept in the locked position during the entire storage period.

Engines shall be preserved in accordance with the applicable provisions of Military Specification MIL-P-10062.

The hydraulic pump shall be thoroughly drained, and treated as recommended by the manufacturer for long-term storage.

Hydraulic hoses shall be stored in suitable crates or containers. Before placing the hoses in storage, they shall be completely drained and flushed so that no explosive vapors can build up during the storage period. The storage area shall be cool, well-ventilated, dry, and dark. The storage temperature shall be within 32°F to 100°F, and the storage area shall not be near any equipment which generates ozone.

II. PACKAGING, PACKING, SHIPPING, AND STORAGE

2.2 STORAGE

2.2.1 Buoy - Continued

Hydraulic control valves and piping shall be drained and coated with Type P-10 Grade 2 preservative.

All open connections and ends shall be plugged or capped to keep out moisture. Exterior operating parts of valves and components shall be coated with Type P-2 preservative.

Bilge pumps, compressors, etc. shall be completely drained of water. All openings in the interior of these units shall be sealed with metal caps or wood plugs, secured to resist removal.

Fuel tanks and water piping systems shall be completely drained. Connections shall be broken at the lowest point to insure complete drainage of the systems. After the systems are dry, fuel tanks and water piping systems shall be fog-coated with Type P-10 preservative, excess preservative allowed to drain, and all connections re-made. Fuel filter and dehydrator elements shall be removed and tags placed on the filters and dehydrator elements to indicate this. All valves shall be full-open, and stems shall be coated with P-1 preservative and

II. <u>PACKAGING, PACKING, SHIPPING, AND STORAGE</u>

2.2 <u>STORAGE</u>

2.2.1 <u>Buoy - Continued</u>

then fully closed. Packing glands on all valves shall be loosened.

2.2.2 <u>Anchors and Anchor Chains</u>

Anchors and anchor chains shall be coated with Type P-1 preservative (unless already painted), and tagged to indicate intended use.

Anchors and anchor chain shall be stored so that they are not directly exposed to the weather.

2.2.3 <u>Mooring Lines</u>

The chain ends, senhouse slip-hooks, and various metal fittings shall be coated with Type P-1 preservative (unless already painted), tagged to indicate intended use, and stored so as to be protected from the weather. Nylon rope and PVC floats shall be stored so that they are not exposed to sunlight or any corrosive atmosphere.

2.2.4 <u>Hose System</u>

Whenever possible, the submarine and floating hose shall be stored in their original shipping containers. Before putting the hose in storage it should be completely drained, and any explosive vapors flushed out. The hose

2.2 STORAGE

2.2.4 Hose System - Continued

shall be stored so that air can circulate through it, and it shall be laid out on straight, solid sections. The storage space shall be cool, dry, and dark, and the hose shall be covered to protect it from the direct or indirect rays of the sun. The storage temperature shall not be less than $32^{\circ}F$ or more than $100^{\circ}F$. The hose shall not be stored adjacent to or near any equipment which generates ozone.

The hose floats shall be stored under the same environmental conditions as the hose, and miscellaneous clamps, bolts, and fittings shall be boxed, marked, and stored in a protected, dry place.

2.2.5 Miscellaneous Items

Any miscellaneous loose items such as hand tools, wire rope or chain fittings, shall be boxed, marked, and stored in a warehouse, or in accordance with the manufacturer's recommendations. Any items not specifically covered in this specification shall be stored in accordance with the applicable provisions of Military Specification MIL-P-14265. Any preservatives specified herein shall conform to Military Specification JAN-P-116.

SECTION III

III. INSTALLATION PROCEDURES

3.0 INTRODUCTION

This document, required under USA-ERDL Contract No. DA-44-009-AMC-841(T), lists the equipment and manpower required and describes the methods to be used to transport and install the Mono-Mooring System.

The purpose of this procedure is to enable the rapid assembly and installation of the Mono-Mooring System with minimum troop and equipment support from an Engineer Port Construction Company. It is required that the installation be made with a minimum use of divers in sea state 2 and water depths ranging from 60 to 150 feet.

Two basic plans of operation are covered in this manual, although it is recognized that in a practical situation, considerable variation of the listed sequence of events may occur. In most cases, deviations from the prescribed pattern have been accounted for; however, in cases where the operational requirements vary considerably from the two approaches covered, it is assumed that the sequence of events may be modified to suit the particular situation.

The first plan assumes that the Mono-Mooring System shall be transported from a storage area remote from the installation site. The system components shall be loaded aboard a transport vessel at the storage area, transported to the installation site, offloaded or transferred to the installation vessel, and then installed at the site.

III. INSTALLATION PROCEDURES

3.0 INTRODUCTION - Continued

The second plan assumes that the system shall be transported from the storage area to an intermediate staging area near or adjacent to the installation site. The system components shall be offloaded and stored for an indefinite period, and then later assembled and loaded aboard the installation vessel, transported a short distance to the site, and installed.

Additional equipment and personnel which might be required for the installation are listed in Section IV, "Recommended Personnel and Equipment Required for the Installation of Mono-Mooring System".

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.1 Loadout

3.1.1.1 Vessels and Equipment Required

The equipment required for loadout of the system shall be capable of lifting, setting, and positioning the various components of the system. A 180-ton capacity crane with sufficient reach will be required to lift aboard and position the buoy. In addition to the 180-ton crane, the ship's cargo-handling booms must have a minimum capacity of ten (10) tons.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.1 Loadout

3.1.1.1 Vessels and Equipment Required - Continued

If an LST is used, this ten-ton capacity will have to be furnished by its cargo-handling booms or by a crawler crane installed on the deck. If a crawler crane is not used, a skid-mounted winch shall be utilized to properly position the various components of the system for offloading.

3.1.1.2 Preassembly of System Components

Prior to being lifted aboard the transport vessel, the disposition of the various system components shall be as follows:

1. Buoy shall be complete, with rotating deck installed, and locked in position.
2. Swivel shall be completely assembled and installed in the buoy.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.1 Loadout

3.1.1.2 Preassembly of System Components - Continued

3. The product piping shall be complete and all terminations shall be sealed with blind flanges.
4. The hydraulic and bilge systems shall be complete, including the piping, engine, pump, reservoir and electrical wiring installed. The control panel, navigational and work lights shall not be installed.
5. Anchors and chain shall be detached, and anchor legs shall be stowed in continuous lengths.
6. Mooring lines shall be as nearly fully assembled as possible.
7. Submarine and floating hose shall be assembled in lengths as long as can be accommodated by the deck arrangement of the transport vessel, and handled by the

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.1 Loadout

3.1.1.2 Preassembly of System Components - Continued

vessel's loading and unloading equipment.

8. One (1) coat of anti-fouling paint and anodes for cathodic protection shall be applied and attached as required by the specifications and drawings.

3.1.1.3 Loading and Tie-Down Instructions

All components shall be lifted aboard and positioned on the transport vessel as shown in Figure 1. The anchor chain may be lifted aboard and deposited in the chain boxes in bights. The hose shall be lifted aboard in sections, and the mooring lines, anchors, and miscellaneous items shall be lifted as required.

The buoy shall be positioned on the launching ways and tied down as indicated in Figure 1 and Draw-

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.1 Loadout

3.1.1.3 Loading and Tie-Down Instructions - Continued

ing No. USA-2971, Sheets 900 through 906. All other components shall be secured in accordance with good marine practice.

3.1.2 Offloading System at Installation Site

3.1.2.1 Equipment Required

The transport vessel shall have a minimum lift capacity of ten (10) tons. If a dry cargo ship is used, the boom capacity shall be at least ten (10) tons in each of two adjacent booms. If an LST is used, it shall have either a ten-ton boom capacity ; or a crawler crane, with the abovementioned capacity capable of lifting loads well outboard from the side of the ship, shall be installed on the deck.

In addition to the above requirements, the following special installation equipment will be required:

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.2 Offloading System at Installation Site

3.1.2.1 Equipment Required - Continued

1. Chain transfer boom with hydraulically-driven wildcat, as shown on Drawing No. USA-2971, Sheets 912 through 916 and Figure 2.

2. Storage bins for chains, with swivel idler sheave as illustrated on Drawing No. USA-2971, Sheets 907, 909, 910 and 911.

3. One (1) winch barge as shown in Figure 3, equipped with winches, anchors, snatch blocks, air compressor, and wire rope, as required.

4. One (1) A-frame barge as shown in Figure 4, equipped with anchors, winches, A-frame, snatch blocks, sheaves, and wire ropes, as required.

5. Buoy launching ramps, as shown on Drawing No. USA-2971, Sheets 900 through 906.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.2 Offloading System at Installation Site

3.1.2.1 Equipment Required - Continued

6. Two (2) LCMs, one equipped with a warping tug kit to assemble submarine and floating hoses to proper length.

7. One (1) skid-mounted windlass, with hydraulic accessories, as shown on Drawing No. USA-2971, Sheets 919 and 922.

8. One (1) medium-size tugboat, equipped with towing winch or powered capstan (LOA 100 - 120', twin screw, 1000 BHP minimum).

3.1.3 Overboarding or Transfer of System Components to Installation Barges

The buoy will be launched from the LST or dry cargo vessel using the ramps illustrated on Drawing No. USA-2971, Sheets 900 through 906. The transport vessel shall be ballasted to as low a freeboard as possible. Freeboard shall be within the limits of 15 to 25 feet.

Prior to launching, the buoy shall be inspected to assure that the rotating deck is

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.3 Overboarding or Transfer of System Components to Installation Barges - Continued

securely locked in position, that the A-frame is secured with guy wires, the diesel engine is securely bolted and braced, and that its longitudinal axis is as nearly parallel to the direction of launch as possible. The upper section of the ramp shall be securely attached to the buoy, and will be recovered by the ship's cargo handling gear after launch.

After entry into the water, the buoy will be towed away from the site and anchored until ready for attachment of anchor legs.

3.1.3.1 Anchor Chain

The anchor chain shall be transferred to the winch barge as shown in Figure 2. This transfer shall be accomplished by using the hydraulically-driven wildcat and chain transfer boom which will be positioned to span from the ship to the barge. The chain transfer boom shall be supported on the ship by the small A-frame, with a swivel

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.3 Overboarding or Transfer of System Components to Installation Barges

3.1.3.1 Anchor Chain - Continued

connection allowing movement between the ship and barge. See Drawing No. USA-2971, Sheet 912.

3.1.3.2 Anchors

Anchors shall be transferred from the LST or dry cargo vessel to the A-frame barge by use of the ship's lifting gear. Winches and snatch blocks shall be available to position the anchors on the barge as required.

3.1.3.3 Hose System

The floating and submarine hoses shall be lifted or skidded off in sections. These hose sections will be towed away from the site and anchored. The sections shall be made up into final lengths, and capped with blind flanges using LCM #1, then anchored again until ready for installation.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.3 Overboarding or Transfer of System Components to Installation Barges - Continued

3.1.3.4 Mooring System and Miscellaneous Items

Mooring lines, tag buoys, and miscellaneous items will be lifted aboard the winch barge by the ship's cargo-handling gear.

3.1.4 Installation of System

3.1.4.1 General

Inventory

The following methods are based upon having a prior survey made, and having the required marker buoys in position. Also, the submarine pipeline with its terminal junction shall be installed and marked.

ref 1909 - TVF

3.1.4.2 Preparation for Installation

In preparing for the installation, vessels shall be loaded and system components shall be located as follows:

1. Buoy floating and anchored away from installation site.
2. Anchors aboard A-frame barge.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.2 Preparation for Installation -Continued

3. Anchor chain aboard winch barge.
4. Hose floating and anchored away from installation site.
5. Mooring lines and other miscellaneous equipment stowed on board the winch barge.

3.1.4.3 Preliminary Sub-System Checkout

Prior to moving the buoy to the installation site, the control panel, aids to navigation and work lights shall be installed. After all electrical and hydraulic system connections have been completed, an operational check shall be conducted on the engine, hydraulic system, and electrical systems. The hydraulic system shall be ready for operation as required during final installation on the buoy. A check shall be made on the deck-locking mechanism to determine that the locking pins are operable. Deficiencies in any of the

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.3 Preliminary Sub-System Checkout - Continued

above shall be corrected before the buoy is moved to the installation site.

3.1.4.4 Installation Procedure

1. The winch barge, loaded with anchor legs, shall be tied alongside the A-frame barge with both barges in a position adjacent to the anchor site. See Figure 5.

2. End of chain shall be passed from the stern of the winch barge under the aft starboard anchor line of the A-frame barge; then, using the A-frame, shall be shackled to the aftmost STATO anchor on the A-frame barge.

3. Anchor shall be lifted overboard and lowered to the bottom, using the A-frame.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

4. Forward starboard anchor shall be retrieved by tug and stowed aboard the A-frame barge.
5. The bow anchor of the winch barge shall be passed to the tug boat, towed out beyond the buoy site, and then set.
6. Tug shall return to assist winch barge in paying out anchor leg.
7. Winch barge shall be released from A-frame barge, and simultaneously haul in the bow anchor line and pay out anchor leg over the stern. Azimuth is controlled by the tug. See Figure 6.
8. A-frame barge shall haul in remaining anchors and proceed under tow of LCM #2 to next anchor site.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

9. After anchor leg is fully payed out, the bitter end shall be lowered to the bottom and buoyed off.

10. Bow anchor shall be recovered, and tug shall tow winch barge to the next anchor position.

11. After all anchor legs have been placed, the winch barge shall be brought into position over the buoy location, and the anchors set in opposite pairs, as shown in Figure 7. The buoyed ends of the anchor legs shall be hauled aboard the winch barge. One leg shall be secured to the barge, and the other attached to the line from the pulling winch. Then, by winching in, the anchors shall be pulled against each other until a setting

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

force of 100,000 pounds is exerted.

12. Prior to moving the buoy to the installation site, the preliminary sub-system check-out shall be performed.

13. After all anchor legs have been set, the winch barge shall be anchored adjacent to the buoy site. See Figure 8. The buoy shall then be brought alongside and secured to the winch barge. The A-frame barge shall then be secured to the buoy and its stern anchors set as shown. Anchors 1 and 2 of the winch barge shall now be retrieved by the tug.

14. The ends of the first two anchor legs shall be hauled aboard the winch barge with a snatch block arrangement as

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

shown. Wire lines shall be lowered from the buoy A-frame and barge A-frame, passed through the chain stoppers on the buoy, and then passed over to the winch barge.

15. These lines shall be attached to the anchor legs. By gradually paying out with the winches on the winch barge and pulling in with the buoy A-frame and the barge A-frame, the anchor legs are now engaged in the chain stoppers. The lines from the winch barge shall be disconnected. It should be noted that in water depths greater than 100 feet, the buoy A-frame with a single line pull will not be capable of pulling the anchor leg through the stopper with a

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

single-part line. In this event, all eight anchor legs shall be secured with the A-frame barge.

16. The first two legs shall be tensioned slightly to fix the location of the buoy.

17. The A-frame barge shall remain in the same position, and operations 14 through 16 shall be repeated for the third and fourth anchor legs.

18. A-frame barge and winch barge shall be moved to a position adjacent to the buoy, but 90 degrees to the position listed in Item 11 13 hereof. See Figure 9.

19. LCM #1 warping tug shall depart to pick up submarine hose.

20. Anchor legs 5, 6, and 7 shall be attached as stated in Items 14 and 16.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

21. Anchor leg 8 shall be left unattached and buoyed off until the attachment of the submarine hose has been completed.

22. LCM equipped with a warping tug kit shall arrive at site with made-up submarine hose.

23. LCM shall drop bow anchor, pass a stern line to the buoy, and position its stern directly over the end of the pipeline.

24. A guide line shall be lowered from the LCM's stern and connected to a fitting on the hose trough. See Figure 10 and Drawing No. USA-2971, Sheet 908. This line shall then be made fast to the LCM.

25. A hose and pendant shall be shackled to the guide line.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

26. The buoy end of the submarine hose shall be secured to the winch barge near a compressed air outlet. Air lines shall be attached to the special blind flanges on the buoy ends of the hose, and the hoses shall be blown out to remove any accumulated water.

27. The lower end of each hose shall be flooded by opening the control valves at the upper end. The lower end shall follow the guide line to the bottom, and shall then be in a position adjacent to the pipeline flange.

28. The hose flanges shall be seated in a guide trough by divers, and then pulled into position using a comealong, or similar device. See Figure 10.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

29. Hose flanges shall be bolted to pipeline flanges by divers.

30. Adjustments shall be made in the buoyancy of the submarine hose by changing the amount of flooding, using compressed air from the winch barge. This will facilitate the maneuvering of the hose into position under the buoy.

31. The buoy A-frame shall be re-positioned over the swivel and re-reaved for single-line operation; then a line from the buoy A-frame shall be passed through the swivel well and under the buoy and connected to the upper end of the two submarine hoses.

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

32. The hoses shall be hauled under the buoy and temporarily tied off to pad-eyes located in the center well.

33. Two special guide lines shall be passed through the bolt holes on one lower swivel flange, and connected to one of the hose flanges, as shown in Figure 11.

34. The blind flange and air fittings shall be removed from the first hose.

35. The hose flange shall be pulled up and mated with the swivel flange and then bolted on.

36. The second hose shall be connected to the swivel, using the method described in Items 33, 34 and 35.

37. Divers shall remove floats to give the submarine hose the

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.4 Installation of System

3.1.4.4 Installation Procedure - Continued

desired configuration.

38. Anchor leg 8 shall now be connected to the buoy as stated in Items 14 through 16.

39. LCM #2 shall bring the end of the made-up floating hose to the side of the buoy.

40. Using the buoy A-frame to lift and align the hose flange to the buoy manifold flange, divers shall now connect the floating hose to the buoy.

41. Anchor legs shall be adjusted for correct initial tension.

42. Mooring lines shall be attached to the buoy.

43. Installation is now complete, and test checkout of buoy sub-systems may commence.

3.1.5 Final Test and Checkout of Sub-Systems

1. After the buoy has been installed, the final checkout of all engine, hydraulic, and electrical systems shall begin. Any equipment

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.5 Final Test and Checkout of Sub-Systems - Continued

requiring lubrication, fuel, or water shall be serviced as recommended by the equipment manufacturer.

2. Sumps on all lubricating oil and fuel tanks shall be sampled for the presence of water, and if water is present, they shall be drained until lubricating oil or fuel are in evidence.
3. Solenoids and fans on ventilating equipment shall be operated to insure that there are no sticking solenoids or locked motors.
4. Bilge pump sumps shall be filled with sea water to check operation of automatic switches, and determine that pumps are free and in operating condition.
5. Saltwater systems shall be checked for leaks in hoses and system connections. Packing glands on valves and pumps shall be inspected and tightened as required.
6. Hydraulic valves and piping shall be checked for leaks.
7. Locking mechanisms for both the rotating deck and the overboard product piping

III. INSTALLATION PROCEDURES

3.1 SYSTEM LOADED OUT AND TRANSPORTED DIRECTLY FROM STORAGE AREA TO INSTALLATION SITE

3.1.5 Final Test and Checkout of Sub-Systems - Continued

swivels shall be checked to insure that all parts are free-moving and operable.

8. Navigational aids package shall be checked to insure that all connections have been made and all equipment is in operable condition.

9. All electrical lighting and power circuits shall be checked to insure that they are operable.

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.1 Loadout

3.2.1.1 Equipment Required

The equipment required for loadout of the system shall be in accordance with Section 3.1.1.1.

3.2.1.2 Loading and Tiedown Instructions

The loading and tiedown instructions are the same as previously discussed for Section 3.1.1.3 with the following exceptions:

1. If 180-ton lift capacity is available at the staging area,

III. INSTALLATION PROCEDURES

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.1 Loadout

3.2.1.2 Loading and Tiedown Instructions - Continued

the buoy may be positioned directly on the deck of the transport vessel, in lieu of the launching ways.

2. If the buoy is to be stored for an extended or indefinite period of time prior to installation, anti-fouling paint shall not be applied, and the anodes for cathodic protection shall not be installed at this time.

3.2.2 Offloading System at Staging Area

3.2.2.1 Equipment Required

If the system is to be transported to, unloaded, and stored at a staging area prior to installation, the transport vessel will be required to meet all conditions listed in Section 3.2.1. In addition, the same equipment will be required for the installation of the system. If

III. INSTALLATION PROCEDURES

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.2 Offloading System at Staging Area

3.2.2.1 Equipment Required - Continued

the system is to remain in storage at the staging area for an extended or indefinite period of time, either 180-ton capacity lifting equipment or a system of ways and skids whereby the buoy could first be launched and then winched ashore to the desired storage area will be required. The anchors, chain, hose, and miscellaneous items shall be offloaded using a procedure similar to that described in Section 3.1.3.

3.2.3 Loadout from Staging Area

3.2.3.1 Equipment Required

The equipment required for loadout shall include a crane with a 25,000 pound capacity rating at a radius sufficient to reach from the crane's dockside or shore location to the extreme seaward side of the installation barge when it is tied

III. INSTALLATION PROCEDURES

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.3 Loadout from Staging Area

3.2.3.1 Equipment Required - Continued

alongside the dock. Suitable methods for dry docking or launching the buoy shall be provided.

Additional equipment will be required as follows:

1. Storage bins for chain, with swivel idler sheave, as illustrated on Drawing No. USA-2971, Sheets 907 and 909 through 911.
2. One (1) A-frame barge, as shown in Figure 4, equipped with anchors, winches, A-frame, snatch blocks, and wire rope, as required.
3. One (1) winch barge, as shown in Figure 3, equipped with winches, air compressor, anchor winches, snatch blocks, and wire rope, as required.
4. Two (2) LCMs, one equipped with a warping tug kit.

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ENGINEER DESIGN OF A MONO-MOORING SYSTEM.(U)

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III. INSTALLATION PROCEDURES

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.3 Loadout from Staging Area

3.2.3.1 Equipment Required - Continued

5. One (1) skid-mounted windlass with hydraulic accessories as shown on Drawing No. USA-2871, Sheets 919 and 922.
6. One (1) medium-size tugboat, equipped with towing winch or power capstan, LOA 110' - 120', twin screw; BHP-1000 minimum.
7. It has been assumed that welding machines, acetylene cutting rig, wire rope, fittings, block sheaves, miscellaneous spares, and small tools will be available as needed.

3.2.3.2 Preassembly of System Components

The disposition of various system components shall be as specified in Section 3.1.1.2.

3.2.3.3 Loading and Tiedown Instructions

The A-frame barge and the winch barge shall be loaded out as shown in Figures 3 and 4. All components

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.3 Loadout from Staging Area

3.2.3.3 Loading and Tiedown Instructions - Continued

shall be lifted aboard the transport vessel and secured in accordance with good marine practice.

3.2.3.4 Launching of the Buoy

The buoy shall be launched using wooden launching ways, by excavating around it, or by other means dictated by the equipment available at the staging area. The rotating deck shall be in the locked position, all hatches and hull openings shall be secured, blind flanges shall be installed at all openings of the product piping system, chain stoppers shall be installed, the A-frame shall be secured, and the control panel, aids to navigation and work lights shall be stowed aboard the winch barge.

3.2.3.5 Launching of the Hose

Both the floating hose and the submarine hose shall be launched and

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.3 Loadout from Staging Area

3.2.3.5 Launching of the Hose - Continued

assembled in the water with blind flanges covering all openings. Any water which may accumulate in the base during launching shall be blown out by the use of compressed air.

3.2.4 Transportation from Staging Area to Site

3.2.4.1 Equipment Required

Equipment required to transport the Mono-Mooring System shall be as described in Section 3.2.3.1.

3.2.4.2 Preparation for Towing

The buoy shall be tied off close to the stern of the winch barge but with enough line so that it will not ride up on the barge. A towing bridle shall be rigged for the winch barge, and connected to a long towing hawser from the tug.

The completely assembled submarine and floating hoses shall be tied to the stern of the A-frame barge, and hawsers shall be connected

III. INSTALLATION PROCEDURES

3.2 LOADOUT AND TRANSPORTATION FROM STORAGE AREA THROUGH STAGING AREA TO INSTALLATION SITE

3.2.4 Transportation from Staging Area to Site

3.2.4.2 Preparation for Towing - Continued

from both LCM's to the bow of the barge.

Both tows are now ready for departure to the installation site.

3.2.5 Installation at Site

Installation of the Mono-Mooring System at the site shall be as specified in Section 3.1.4.4.

Removed Drawings

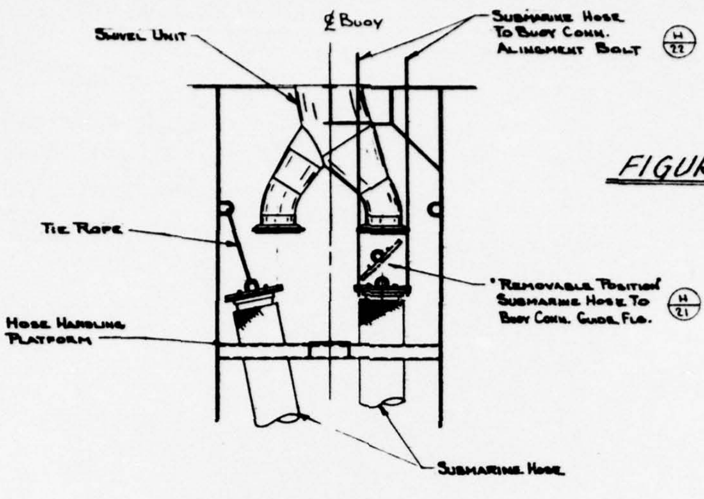
The following drawings have been removed from this book and placed in the draft copy of the MORDC Mono-Mooring Report:

829
831
830
832
833
834

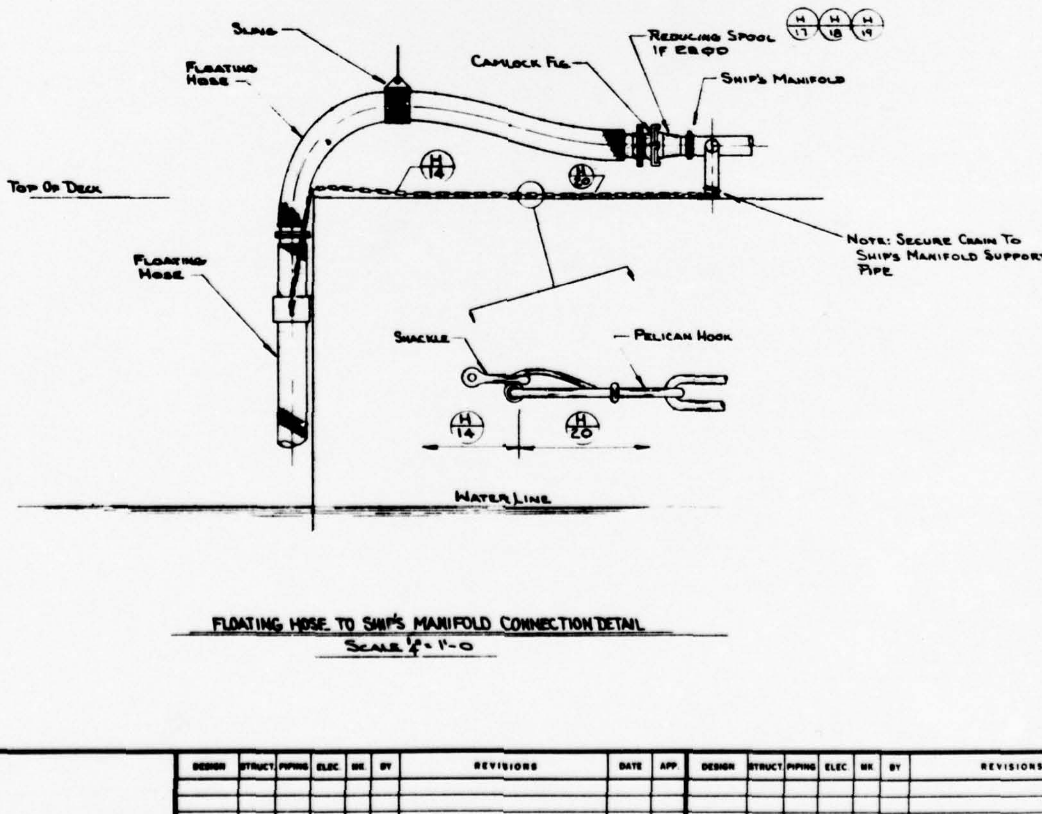
27 June 69

[illegible]

FIGURE 11



SUBMARINE HOSE TO BUOY CONNECTION DETAIL
Scale 3/8" = 1'-0



FLOATING HOSE TO SHIP'S MANIFOLD CONNECTION DETAIL
Scale 1/4" = 1'-0

DESIGN	STRUCT	PIPING	ELEC	MK	BY	REVISIONS	DATE	APP	DESIGN	STRUCT	PIPING	ELEC	MK	BY	REVISIONS	DATE	APP	DESIGN	STRUCT

1

2

BILL OF MATERIAL

FIND No	DWG. No.	QTY	NOMENCLATURE	SPEC.	MATL.
H 14	SHT. 841		HOSE HANDLING CHAIN		
H 20	SHT. 841		HOSE TIE DOWN CHAIN		

REFERENCE DRAWINGS

SHT No.	TITLE
840	HOSE ASSY.
841	HOSE MISC DETAILS

NOTES

	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 700
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: GC Lee
J. RAY McDERMOTT & CO., INC.
DATE: 2-18-66

ENGINEERS APPROVAL	BY	DATE
PROJECT	GCL	2-18-66
STRUCTURAL	GLE	2-18-66
PROCESS		
MECHANICAL		
ELECTRICAL		
INSTRUMENT		
FAB. CHECK	GW	2-18-66
PROOF CHECK		

MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH
& DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS — CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
S. Guillory	AS NOTED	2-18-66	USA-2971
FABRICATORS JOB NO.		J. RAY McDERMOTT JOB NO.	SHEET NO.
56017			842

HOSE INSTALLATION DETAILS

SECTION IV

IV. RECOMMENDED PERSONNEL AND EQUIPMENT REQUIRED FOR INSTALLATION OF MONO-MOORING SYSTEM

4.0 GENERAL

As a contractual requirement, Document No. TO&E 5-129E, "Table of Organization and Equipment for a Full Strength Engineer Port Construction Company" has been reviewed. This review was necessary to fulfill Item 2.a.4 of Exhibit "A" of Contract No. DA-44-009-AMC-41(T), "Recommended Additional Personnel and Equipment Required to Install the Mono-Mooring System Not Contained in TO&E 5-129E".

4.1 RECOMMENDED PERSONNEL

The following is a list of personnel required to install the Mono-Mooring System in accordance with Section III, "Installation Procedures" of this report:

1 - Section chief or job superintendent who will be responsible for the progress of the job at all times.

1 - Construction engineer who will be on the job site at all times in a supervisory and advisory capacity.

*1 - Crew for a medium size tug, consisting of the following:

1 - Captain

1 - Mate

2 - Engineers

1 - Oiler

1 - Cook

2 - Deck hands

IV. <u>RECOMMENDED PERSONNEL AND EQUIPMENT REQUIRED FOR INSTALLATION OF MONO-MOORING SYSTEM</u>

4.1 <u>RECOMMENDED PERSONNEL - Continued</u>

1 - Crew each for two (2) LCMs as follows:

  2 - Captains, one for each LCM

  6 - Deck hands, three for each LCM

1 - Complement of divers and helpers consisting of:

  3 - Senior divers

  1 - Diver

  3 - Senior diver's helpers

  1 - Diver's helper

1 - Welding crew, as follows:

  1 - Welder foreman

  2 - Senior welders

  2 - Welder helpers

  1 - Electrician

1 - Piping crew, as follows:

  2 - Pipeline SPs

  2 - Pipeline helpers

1 - Air compressor operator

1 - Crane operator

3 - Hoist operators

4 - Riggers to handle wire lines, fittings, and miscellaneous rigging

4 - Construction helpers to perform miscellaneous duties on barges and ship

1 - Mechanic to maintain all installation equipment

50

*These personnel not contained in TO&E 5-129E.

IV. RECOMMENDED PERSONNEL AND EQUIPMENT REQUIRED FOR INSTALLATION OF MONO-MOORING SYSTEM - Continued

4.2 RECOMMENDED EQUIPMENT

The following is a list of equipment required to install the Mono-Mooring System in accordance with paragraph 3.3.3 of this report, entitled "Installation Procedure":

4.2.1 Vessels

*1 - Tug boat, equipped with towing winch or powered capstan having the following dimensions: LOA 100' to 120', twin screw, 1000 BHP minimum.

*2 - Barges measuring 33 feet by 120 feet, equipped with side and bow anchors, as illustrated in Section III, "Installation Procedures".

*2 - LCMs, one with warping tug kit.

*This equipment not contained in TO&E 5-129E.

4.2.2 Handling Gear

*1 - Chain transfer boom, as shown on Drawing No. USA-2971, Sheets 912 through 916.

*16 - Chain storage boxes as shown on Drawing No. USA-2971, Sheets 907 through 911. The minimum number of chain storage boxes required for the installation will be ten (10); however, sixteen (16) chain storage boxes will be necessary if it is not desirable to transfer the boxes from the ship to the barge

IV. RECOMMENDED PERSONNEL AND EQUIPMENT REQUIRED FOR INSTALLATION OF MONO-MOORING SYSTEM

4.2 RECOMMENDED EQUIPMENT

4.2.2 Handling Gear - Continued

after they are empty.

*1 - Set of launching ways as shown on Drawing No. USA-2971, Sheets 900 through 906.

*1 - Skid-mounted windlass as shown on Drawing No. USA-2971, Sheet 919, and Figures 3, 5, and 6 of Section III, "Installation Procedures".

*10 - Marker buoys to be used for marking the location of anchors, buoy and submarine pipeline terminal junction.

*8 - Tag buoys with wire line pendants, as illustrated in Figure 8 of Section III, "Installation Procedures".

*1 - Double snatch block assembly with a rated capacity of 50 tons.

*1 - A-frame, mounted on the A-frame barge, with a 40-ton capacity, and a minimum overboard reach of 12 feet.

*2 - Carpenter stoppers for 1-3/8" wire rope, positioned as illustrated in Figure 3 of Section III, "Installation Procedures".

*1 - Hose trough, as shown on Drawing No. USA-2971, Sheet 908.

IV. RECOMMENDED PERSONNEL AND EQUIPMENT REQUIRED FOR INSTALLATION OF MONO-MOORING SYSTEM

4.2 RECOMMENDED EQUIPMENT

4.2.2 Handling Gear - Continued

1 - Crawler crane having a 20-ton capacity, with a 50-foot boom. (Required only if transport vessel is an LST.)

*7 - Winches as specified in Figures 3 and 4 of Section III, "Installation Procedures", and as listed below:

- 1 - Large 2-drum winch, as specified in USA/ERDL PD, dated 15 March 1965, equipped with 1500 feet of 1-3/8" diameter 6 x 19 XIPS IWRC wire rope.
- 2 - Triple-drum pipeline pulling winches similar to MIL-W-18574B, Size 40, equipped with 1100 feet of 1-1/8" diameter 6 x 19 XIPS IWRC wire rope.
- 4 - BU-30s conforming to MIL-W-18574B, Size 30, equipped with 1000 feet of 1-1/8" diameter 6 x 19 XIPS IWRC wire rope.

1 - Air compressor, diesel driven, 600 cfm, 100 psi.

- Diving equipment for three (3) divers, sufficient for 200-foot water depth.

- Welding machines, acetylene cutting rigs, wire rope, fittings, blocks, sheaves and small tools, as required.

* This equipment not contained in TO&E 5-129E.

TOE 5-129E Removed for
Final Report, 30 June 69. Hm

SECTION ▲

V. OPERATIONAL PROCEDURES

5.0 SEQUENCE OF OPERATIONS

The proper sequence for connecting and disconnecting the mooring lines and cargo hose shall be adhered to. When mooring the tanker, the mooring lines shall always be secured before connection of the cargo hose is commenced. Similarly, when the tanker is departing the buoy, the cargo hose shall be completely disconnected before separation of the ship from the mooring lines is begun.

5.1 SAFETY PRECAUTIONS

Extreme care shall be exercised to insure that at no time shall the tender vessel come between the buoy and the tanker.

All personnel shall be removed from the buoy during the mooring operation.

5.2 MOORING DOWNWIND

Mooring to the buoy downwind or down-current shall be avoided whenever possible. If a downwind or down-current mooring must be accomplished, the stern of the tanker shall be held into the wind or current by use of the engines and the helm, until the bow mooring lines can be secured. See Figure 12. The tanker may then be allowed to slowly swing downwind or down-current, and by discreet use of the engines and rudder(s), the bow may be kept away from the buoy.

5.3 MOORING CROSSWIND

Mooring to the buoy crosswind or cross-current shall also be avoided whenever possible. If a crosswind or

5.3 MOORING CROSSWIND - Continued

cross-current mooring must be accomplished, the tanker shall approach the buoy as shown in Figure 13 , and attempt to become dead in the water well upwind and short of the buoy. The engines and helm shall be used to hold the tanker's head into the wind as steadily as possible. This will keep the bow as near the buoy as is possible under the circumstances, and allow the maximum time for passing and attaching the 1-1/8" diameter tail lines. Once these lines have been attached, the tanker shall be allowed to swing to a downwind position and heave itself up to the buoy for final attachment of the mooring line.

5.4 MOORING LINE HOOKUP

5.4.1 Preparation for Mooring Operation

The tender vessel and its crew shall start preparations for the mooring operation prior to the arrival of the tanker, in accordance with Drawing No. USA-2971, Sheets 827 and 828.

Before preparations commence, only the floating hoses and the floating sections of the mooring lines are installed with the buoy. The wire rope tail lines and the other mooring fittings are aboard the tender vessel.

Prior to the arrival of a tanker, the crew of the tender vessel shall perform the following duties:

V. OPERATIONAL PROCEDURES

5.4 MOORING LINE HOOKUP

5.4.1 Preparation for Mooring Operation - Continued

1. If the current is less than one knot, tow the floating hose 120 degrees away from the direction by which the tanker will approach. If the current is one knot or greater, the tanker will approach against the current, with the hose and buoy 100 to 300 feet to its port side.

2. Determine that mooring lines are free from entanglement and are floating away from the buoy.

3. Retrieve the sister plates at the extreme end of the floating mooring lines, shackle the 350-foot long 1-1/8" diameter tail lines to the plates, and then pay out all of the tail lines except the bitter ends.

4. Remain on station at the rendezvous location and prepare to pass the lines to the tanker. Well in advance of the tanker's final approach to the buoy, her crew shall place messenger lines overboard for hauling in the 1-1/8" diameter wire tope tail lines and shall lower lines in readiness for lifting aboard the 2" diameter wire rope bitt lines, Senhouse slip-hooks, and miscellaneous fittings.

V. OPERATIONAL PROCEDURES

5.4 MOORING LINE HOOKUP

5.4.1 Preparation for Mooring Operation - Continued

The tanker's master shall carefully study and analyze conditions affecting the particular mooring site, to be aware of the water depth, tide, current, wind, swell and wave effects, bottom terrain, bank effect, swing, and approach room.

5.4.2 Approach and Mooring

Approaches to the buoy shall always be made into the current, and, whenever possible, into the wind. See Figure 14. Therefore, it is incumbent upon the master or pilot of the tanker to predetermine the optimum approach direction and bring the vessel dead in the water with the bow between 100 to 350 feet from the buoy, as shown in Figure 14.

The tanker shall receive the 1-1/8" diameter tail lines from the tender vessel and haul them aboard through the chocks on the forward bulwark. These lines shall be engaged on the tanker's windlass catheads, and the vessel shall be pulled in toward the buoy.

The tender vessel shall now pass the 2" diameter wire rope bitt lines, Senhouse sliphooks, and miscellaneous fittings aboard the tanker. The

V. OPERATIONAL PROCEDURES

5.4 MOORING LINE HOOKUP

5.4.2 Approach and Mooring - Continued

2" bitt lines shall be secured to the tanker's bitts, and the chain ends shall be assembled on the deck in preparation for attaching them to the sister plates at the end of the mooring lines. The tail lines shall be winched in until the sister plates are inboard of the tanker bulward chocks, and the chain ends from the 2" diameter bitt lines can be shackled to the sister plates. Then the 1-1/8" tail lines shall be eased until the mooring load has been transferred to the bitt lines. The vessel has now been moored to the buoy, and the hose hookup operation may commence.

5.5 MOORING LINE DISCONNECTION

5.5.1 Normal Disconnection of the Mooring Lines

The 1-1/8" diameter tail lines on the ship's cathead shall be re-engaged, and the vessel shall be pulled toward the buoy until the 2" diameter bitt lines are lying slack on the deck.

The 2" diameter bitt lines and fittings shall be disconnected from the mooring line sister plates, and the bitt lines removed from the bitts and passed down to the tender vessel.

V. OPERATIONAL PROCEDURES

5.5 MOORING LINE DISCONNECTION

5.5.1 Normal Disconnection of the Mooring Lines - Continued

Tanker shall back away from the buoy until the tail lines can be passed down to the tender vessel. When tail lines have been passed to the tender vessel, the tanker returns to sea.

The tender vessel can now retrieve the 1-1/8" diameter tail lines and disconnect them from the mooring lines at the sister plates.

5.5.2 Emergency Disconnection of the Mooring Lines

NOTE: IF AT ALL POSSIBLE, RELEASE OF THE MOORING LINES SHOULD BE DELAYED UNTIL THE HOSES HAVE BEEN RELEASED.

Senhouse slip-hook shall be released, causing separation of the mooring and bitt lines. Personnel shall stand clear while the mooring lines, sister plates, and tail lines run free through the forward chock.

The tender vessel shall retrieve the 1-1/8" diameter tail lines, and the 2" bitt lines shall be left on board the tanker if no time is available for passing them to the tender.

5.6 CARGO HOSE HOOKUP

5.6.1 Preparation for Hose Hookup

Before the tanker arrives at the mooring site, personnel of the tender vessel shall have

V. OPERATIONAL PROCEDURES

5.6 CARGO HOSE HOOKUP

5.6.1 Preparation for Hose Hookup - Continued

inspected the floating hoses to be certain that they are in operable condition and have not been damaged by craft operating in the area, or by rough weather.

If there is some question about a particular component, the facility manager shall exercise caution in placing the system in operation and shall carefully watch the entire system during the loading operation.

5.6.2 Hose Hookup

After the mooring operation is completed, the tender vessel shall pass up to the tanker the lengths of hose and adapters necessary to allow connection of these hoses to the vessel's cargo manifold. The floating hose raft shall then be positioned alongside the tanker. With the vessel's hose-lifting gear, each hose shall be lifted individually to the bulwark and then made fast with chains or wire ropes connected to suitably located pad-eyes on the hose end fittings and on the vessel. During the lifting operation, the lengths of hose connected to the tanker manifold shall be aligned with the floating hose end fittings and coupled by use of the quick-disconnect couplings.

5.6 CARGO HOSE HOOKUP

5.6.2 Hose Hookup - Continued

Care shall be employed throughout this phase of the hose hookup not to kink or unduly bend the hoses and to assure that all flanged and coupled joints are tight.

safety

The hose raft shall then be towed away from the tanker side, except when weather conditions are extremely light.

The hose system linking the tanker with the onshore pumping facility is now completely connected. Before the pumps are started up, the valving on the buoy, the hoses at the tanker, and the tanker manifold shall be positioned to a full-open setting since partially-closed valving would increase stresses in the entire system and thus shorten the life of certain major components.

CAUTION: When the hose system is connected, under no circumstances should any valving be closed suddenly without first shutting down the pumps which supply pressure to the system.

5.7 CARGO HOSE DISCONNECT

5.7.1 Preparation for Hose Disconnect

After pumping and flushing operations have been completed and all pumps are shut down, the tender vessel shall position the hose raft alongside the tanker.

5.7 CARGO HOSE DISCONNECT - Continued

5.7.2 Hose Disconnect

After closing the valves at the hose ends, the hoses shall be individually disconnected from the system by use of the quick disconnect couplings. All hose ends shall be fitted with blind flanges or caps. Using the tanker's cargo handling gear, hoses shall be lowered into their respective positions and locked to the hose raft. After all floating hoses have been securely positioned on the hose raft, the tanker personnel shall pass down to the tender vessel the hoses and adapters which were used to connect the hose to the tanker's manifold.

CAUTION: Because hoses will be full of oil when the loading operation is completed, the tanker operator shall employ a method of draining the oil from the hoses between the ship's manifold and the floating hose valving. Spillage onto and over the side of the tanker shall be avoided.

5.8 PREPARATION OF ROTATING DECK

The buoy deck can be rotated to any position either by the tender vessel towing the floating cargo hose, or by the hand winch mounted on the buoy deck. When the tender vessel is employed to rotate the buoy deck, the overboard end of the product piping shall rotate freely, with swivel-type joint-locking pins disengaged. To rotate the deck by

5.8 PREPARATION OF ROTATING DECK - Continued

the use of the hand winch, it is necessary to use snatch blocks and attachments on the buoy structure.

The rotating deck is equipped with two locking mechanisms which allow the deck to be locked in several positions. This locking mechanism is intended for use during installation and maintenance of the buoy.

The locking pins are located in the outer periphery of the rotating deck, and care shall be taken to insure that these pins are in the unlocked position prior to mooring the tanker.

5.9 PREPARATION OF CARGO PRODUCT PIPING

The overboard end of the buoy product piping is equipped with swivel-type joints which allow positioning of the floating cargo hoses in the horizontal plane. *These joints* can be rotated to the desired position and locked to give the cargo hoses a particular lead-off angle within 90-degree limits. These joints shall be in the free, or unlocked, position except when a tanker is moored, or when certain circumstances require a particular hose position. Care shall be exercised to insure that swivel joints are in the unlocked position when the buoy is unattended.

The buoy cargo product piping has been valved to allow for a variety of flow paths. Basically, the system consists of two flow lines with a crossover connection. In a multi-product handling operation, the crossover valve

V. OPERATIONAL PROCEDURES

5.9 PREPARATION OF CARGO PRODUCT PIPING - Continued

shall remain in the closed position. A check shall be made before each tanker mooring operation to insure that all valving is positioned to give the flow paths required.

Figs 12, 13, and 14 placed in MERDC Mono-mooring Report 26 June 69 Hm

SECTION VI

VI. OPERATIONAL TEST PROCEDURES

6.0 INTRODUCTION

Tests and trials to be conducted during the construction of the Mono-Mooring System are given in the volume, "Specifications, Building Mono-Mooring System, February 1966", and should be considered as part of this section. However, because of their importance as part of operational testing, the sections on tests, trials and inspections, swivel testing, and anchor chain stopper testing are repeated herein.

6.1 TESTS AND TRIALS

On completion of the system and prior to delivery by the Builder, all structural items, machinery, product piping systems, hose, and lifesaving equipment shall be thoroughly tested in accordance with the specifications and the requirements of the ABS, USCG, and the AIEE, as applicable, to demonstrate proper working order, suitability for work intended and fulfilled. Any defects which may develop or become apparent in connection with the work shall be corrected prior to delivery by the Builder. The results of all tests and corrections shall be recorded and a copy of the records furnished to ERDL.

All devices, appliances, and fittings for handling weights, taking strains, etc., shall be tested for proper installation. The test load shall be one-and-one-half times the working load for operating tests.

VI. OPERATIONAL TEST PROCEDURES - Continued

6.2 MACHINERY

All machinery shall be tested to demonstrate satisfactory operation and compliance with the requirements of the equipment being tested.

6.3 ELECTRICAL

All electrical machinery, controllers, wiring, etc. shall be tested to demonstrate proper design, installation, and operation of the electrical systems.

6.4 PIPING AND SYSTEMS

All piping and systems (such as bilge, ventilation, product-handling, etc.) shall be tested to demonstrate proper installation, alignment, and operation. All piping shall be hydrostatically tested prior to installation of protective devices and/or coatings.

6.5 INSPECTION

The buoy shall be constructed and equipped under the inspection of and subject to the approval of the ERDL representative, the ABS and the USCG.

All material and workmanship shall be subject to inspection by representatives of the above agencies at any and all times during manufacture or construction. The inspectors shall be advised of the progress of construction and shall be provided with free access at all times to any part of the construction activity. The Builder shall advise the inspectors in every particular as to the Builder's program of work. No significant operation is

6.5 INSPECTION - Continued

to be performed without prior notice being given in sufficient time to allow adequate inspection.

Failure of ERDL during progress of the work to discover materials or workmanship not in accordance with the specifications and drawings shall not be deemed accepted or as a waiver of defects therein. No payment or partial payment shall be construed as acceptance of work or materials which are not in strict accordance with the specifications.

6.6 TEST AND INSPECTION CERTIFICATES

Certificates of Inspection, Certificates of Test, and other necessary certificates and documents covering the approval and indicating the compliance of any part or component of the Mono-Mooring System with the American Bureau of Shipping or other regulatory body, shall be obtained in duplicate by the Builder at his own expense.

6.7 SWIVEL TESTING

To insure satisfactory operation of the product system flow swivel, certain tests shall be conducted to insure operability and tightness of the rotary seals. All tests shall be made after complete installation of the swivel components on the buoy, in accordance with the assembled arrangement of the swivel, as shown on Drawing No. USA-2971, Sheet 871, and as described in Section 3, Paragraph 3.4.1 of the specifications. However, the tests shall also be conducted prior to installation of the swivel into the buoy, as shown on Drawing No. USA-2971, Sheet 874.

6.7 SWIVEL TESTING - Continued

Testing shall be carried out utilizing jet fuel of grade and quality as specified in Section 4, Paragraph 4.1 of the specifications.

Hydrostatic tests shall be applied to insure the effectiveness of the seals as well as the freedom of the swivel to rotate while under hydrostatic loads. Hydrostatic test pressures shall be of the following minimum values:

Static Tests : At 60, 150, and 225 PSI

Dynamic Test : At 150 PSI

Testing order shall be:

1. Static tests at all pressures.
2. Dynamic testing - 15,000 cycles at 150 psi.
3. Static tests repeated.
4. Dynamic testing repeated - 15,000 cycles.
5. Repeat alternation of static and dynamic tests until 100,000 cycles have been completed.

Included in the arrangement for testing shall be an acceptable means for detecting and measuring any fluid loss from inside the flow passages to outside these passages. Leakage of more than 0.5 GPM from any passage will not be acceptable.

Static testing shall be done while the swivel is at rest. Each flow passage shall be pressured internally to each of the pressures cited above, and after individual passages are tested, both passages shall be pressurized

VI. OPERATIONAL TEST PROCEDURES

6.7 SWIVEL TESTING - Continued

simultaneously. Leakage beyond the limit set above will not be acceptable.

Dynamic testing shall be done on individual passages and on both passages simultaneously while the swivel is being rotated 15 degrees in one direction followed by 5 degrees in the opposite direction. Thirty-six back-and-forth motions constitute one complete net revolution. At the end of each 15,000 oscillations, the swivel shall be rotated one full revolution, then the static tests shall be performed again and testing subsequently continued as set forth in testing sequence above. Rates of rotation of the swivel shall be 4 seconds per complete oscillation and 4 minutes per full revolution. Upon completion of the test, the flow passages must have demonstrated the capability of maintaining their seals within limits specified; the swivel must show that it can rotate freely, both during and after the dynamic testing without binding or without requiring the application of excessive power.

The swivel shall be disassembled and examined for signs of excessive wear or distortion at the conclusion of the static and dynamic testing, and should such signs appear, the Contractor shall take the necessary corrective measures to the satisfaction of the Owner.

Adequate safety precautions shall prevail throughout the testing procedures.

6.8 ANCHOR CHAIN STOPPERS TESTING

Each chain stopper shall be subjected to a proof test equivalent to 110% of the proof load of the chain and examined for parts distortion. To assure the ability of the chain stopper to effectively hold the chain, a final load test of each assembled chain stopper shall be made by applying tensile loading to a short length of the specified anchor chain, fixed in a secured position in the chain stopper. The test tensile load to be applied shall be no less than 762,000 pounds.

Records of all tests are to be supplied to the Owner.

6.9 BUOY HULL TESTING

The compartments of the buoy should be individually pressure tested pneumatically prior to the placement of the foam flotation material. Hydrostatic tests should be conducted on the foam after it is installed, or on test blocks of foam to insure that it will withstand the required submergence pressure.

7.0 ASSEMBLED BUOY TESTING

Just prior to installation, the completely assembled buoy should be tested for:

1. Free movement of rotating deck.
2. Pressure tightness of entire piping system, especially the main swivel and expansion joints.
3. Free movement of chain stopper pawls and ability to rotate on trunion bearings.

VI. OPERATIONAL TEST PROCEDURES

7.0 ASSEMBLED BUOY TESTING - Continued

4. Operation of navigational aids, if installed.

5. Damage to buoy hull during shipment or while in storage.

6. Soundness and operability of entire system and all apparatuses.

7.1 TRANSPORTABILITY

Transportability of the Mono-Mooring System should be demonstrated using the equipment recommended by McDermott or another method developed by the Army. The buoy should be launched from the vessel if it is transported to the site by a freighter; or if it is felt that this is not required, the buoy should be towed a suitable distance to demonstrate that it does not have to be fabricated close to the installation site.

7.2 INSTALLATION

After first schooling the Engineer Port Construction Company which is going to install the system by use of either the installation equipment designed as part of Contract No. DA-44-009-AMC-841(T) or, such other equipment as may be available, actual installation should be performed within the time limits prescribed by the Purchase Description.

7.3 OPERATIONAL TESTING

After the Mono-Mooring System is installed, the most conservative test would be first to have tankers in the size range between 22,500 and 70,000 DWT moor to the buoy without taking hose aboard, to demonstrate the effectiveness of the mooring operation. After any deficiencies are corrected and mooring operations are satisfactory, the hose should be taken aboard and the system tested by pumping water through it for a considerable period of time to determine the integrity of the hose and submarine pipeline.

After the integrity of the Mono-Mooring System has been demonstrated, it should be tested in a fully operational capacity. The buoy should be placed in a location where the design weather conditions prevail and where sufficient tanker traffic is available to demonstrate the cargo-handling capabilities of the system over its designed life-span. During this phase, particular notice should be given to the performance of the buoy, mooring lines, and hose when there is no tanker moored to the buoy; the mooring lines should not become excessively entangled and the hose should not wrap around the buoy or become fouled. When the tanker overrides, particular notice should be taken of the reaction of the buoy and the resulting effects of hose pinching and mooring line entanglement.

SECTION VII

VII. DESIGN - DEVELOPMENT OF A RIGID ARM CONNECTION BETWEEN THE TANKER AND THE BUOY

7.0 BACKGROUND

The work covered under this phase of the project was accomplished under Amendment No. 3 to the original Purchase Description of Contract No. DA-44-009-AMC-841(T), Mono-Mooring System, for the Engineer Research and Development Laboratories at Fort Belvoir, Virginia.

During the course of the original mono-mooring project, McDermott as requested to investigate the feasibility of using a rigid-arm or means other than conventional mooring lines for connecting a tanker to a mono-mooring buoy. At that time, the intended purpose of the rigid-arm was to eliminate or reduce the amount of hose required for the system, to improve the overall hose handling operation, to improve the method of mooring the tanker to the buoy, and to reduce the mooring loads imparted to the buoy and the anchor system.

Seven basic approaches were investigated, each one using a different means of connecting the tanker to the buoy. Of the various schemes studied, two approaches - namely, the floating-bow type connection and the buoy-alongside-ship connection appeared to be the most feasible, and to merit additional study and model test work. However, due to the short time available for investigating all of the various approaches, and the limited extent of work done on the two most promising approaches, McDermott

VII. DESIGN - DEVELOPMENT OF A RIGID ARM CONNECTION BETWEEN THE TANKER AND THE BUOY

7.0 BACKGROUND - Continued

did not feel that feasibility could definitely be established without further development and model testing.

Before the abovementioned feasibility work was undertaken, it was learned that Shell Oil Company had been conducting model tests on a rigid-arm configuration incorporating two structural arms which extended outward from the buoy to points located on either side of the ship well aft of the bow. The arms were attached to the ship by taut wire lines.

The Shell approach was structually simple and did not require gimballed connections at the bow of the tanker as did several of the approaches investigated by McDermott. It also overcame the tendency of the tanker to override the buoy.

Recognizing the inherent advantages of the Shell system, McDermott recommended to ERDL that an investigation of the Shell approach be included in any contemplated development work on a rigid connection between the tanker and the buoy.

In response to the above recommendations, ERDL amended McDermott's original contract to provide for additional development work, and evaluation of nine different semi-rigid connection schemes.

VII. DESIGN - DEVELOPMENT OF A RIGID ARM CONNECTION BETWEEN THE TANKER AND THE BUOY

7.0 BACKGROUND - Continued

It was intended that upon the completion of the design development and evaluation phase of this project, McDermott would make a recommendation to ERDL as to the value of model testing of one or two of the most promising approaches developed.

7.1 SCOPE OF WORK

Amendment No. 3 to the contract called for McDermott to investigate the following semi-rigid connection schemes:

A. McDermott's Approach No. 1A - Conventional hawser with a floating or submerged pipe arm.

B. McDermott's Approach No. 1B and No. 6A - Tanker alongside buoy, with submerged pipe arm.

C. McDermott's Approach No. 3A - Foldback rigid-arm, with hose over bow.

D. McDermott's Approach No. 3B - Single telescoping foldback arm.

E. McDermott's Approach 3B - Modified folding arm structure, with bow hose and hydraulic shock cylinders.

F. McDermott's Approach No. 4A - Rigid arm, with topping lead and hydraulic shock cylinders.

G. ERDL'S Approach - Scissoring two-way action line, with swivel floating pipe arm.

H. ERDL'S Approach - Ring buoy and taut wire mooring, with explosive embedment anchors and floating pipe arm.

I. Shell's Approach - Double arm system.

VII. DESIGN - DEVELOPMENT OF A RIGID ARM CONNECTION BETWEEN THE TANKER AND THE BUOY - Continued

7.2 PROJECT ORGANIZATION

Upon authorization from ERDL for an extension to the contract to reflect the expanded scope of work, the project was reorganized. Due to the conceptual nature of this phase of the project, a change in personnel assigned to the project was accomplished to reflect the type of work involved. It was anticipated that a motion analysis would be required of the tanker and buoy. Recognizing this, personnel with the required technical background in terms of both experience and education were assigned to the project. A work flow chart was prepared delineating the various phases of the extended project to assure that adequate emphasis was placed where it was most needed.

7.3 DESIGN CRITERIA - PRELIMINARY

Design criteria were established for the following prime requirements:

1. To eliminate a large part of the hose required by previous methods.
2. To allow the tanker to be moored in a higher sea state and to remain in the mooring and unload in a higher sea state.
3. To reduce the time required to moor the vessel and initiate cargo transfer operation.
4. To reduce unloading time.

7.3 DESIGN CRITERIA - PRELIMINARY - Continued

5. To prevent the tanker from overriding the buoy in calm weather.

In view of the many concepts which McDermott was required to investigate, it was decided to develop each preliminary design up to a point where it became apparent that the particular design was not feasible. In other words, the development effort for each concept was extended until a particular reason such as excessive cost, size, etc. indicated that the design obviously was not feasible. This method resulted in the largest amount of effort being expended on those approaches which appeared to have the most favorable chance of evolving into an operational system.

The following factors were considered, and served to augment the design criteria in developing each approach.

A. Overall geometry of the system.

B. Simplicity of design.

C. Minimum size and weight of structural connections, with particular regard to installability by an Engineer Port Construction Company.

D. Static and dynamic forces resulting from the various environmental elements.

E. Secondary induced dynamic forces generated by the relative motion between the tanker and the buoy.

7.4 EVALUATION OF PRELIMINARY DESIGNS

As the preliminary designs were developed, each was evaluated periodically to determine if it warranted further study. The concepts which were eliminated and the reasons for abandoning the particular approach are listed below:

A. Approach 1A - Conventional hawser, with a floating or submerged pipe arm.

1. The cost was excessive.
2. The draft requirements were too great, requiring an excessive amount of submarine pipeline which would result in high flow losses and extremely high cost.
3. The tanker would override the buoy and possibly destroy the submarine arm.

B. Approach 3A - Foldback rigid arm with hose over bow.

1. Buoy stability was a problem -- a movable counterweight would be required.
2. The complexity of the required machinery was considered excessive.
3. A bow manifold on the tanker, or a means of extending pipe from the midship's manifold to the bow, was required.
4. Cost was excessive, the figure running to roughly $2,000,000, not including installation cost.

VII. <u>DESIGN - DEVELOPMENT OF A RIGID ARM CONNECTION BETWEEN THE TANKER AND THE BUOY</u>

7.4 <u>EVALUATION OF PRELIMINARY DESIGNS - Continued</u>

5. Lack of realiability was anticipated, due to the complexity of the mechanical parts.

C. Approach 3B - Single telescoping foldback arm.

1. This approach was considered more mechanically complex than 1B and 6A, and would require development effort considerably beyond the scope of the contract.

D. Approach 3B - Modified folding arm structure, with bow hose and hydraulic shock cylinders.

1. This approach, in addition to having the drawbacks listed in Approach 3A, was considered even more complex than Approaches 3A and 3B.

E. Approach 4A - Rigid arm, with topping lead and hydraulic shock cylinders.

1. This approach was abandoned for the same reasons as Approaches 3A, 3B, and 3B Modified.

F. ERDL Approach - Scissoring two-way action line, with swivel floating pipe arm.

1. Although it was not anticipated in the early stages of design, after a static force analysis was conducted, this concept was proved unfeasible.

2. The tanker had a tendency to override the buoy, so that tanker deck piping would have been

required to provide a hose manifold connection at the bow of the tanker.

G. ERDL Approach - Ring buoy and taut wire mooring, with explosive embedment anchors and floating pipe arm. Because of its many apparent advantages, such as the possibility of using explosive embedment anchors attached to vertical wire lines to reduce the amount of time required for installation, considerable development work was done on this approach. However, the design was eventually abandoned for the following reasons:

1. In order to develop the required mooring force the buoy became too large and costly even before the required mechanical connections to provide a rotating ring were considered.
2. The installation presented numerous problems because of the requirement for a counterweight weighing approximately 400,000 pounds.
3. Potential interference between the submarine hose and counterweight presented a serious problem. In a deflection situation with the counterweight rising and falling, it would be very difficult to avoid having the counterweight chafe the submarine hose.

VII. <u>DESIGN - DEVELOPMENT OF A RIGID ARM CONNECTION BETWEEN THE TANKER AND THE BUOY</u>

7.4 <u>EVALUATION OF PRELIMINARY DESIGNS - Continued</u>

4. The reliability of wire line working over sheaves was questionable.

H. Shell's Approach - Double arm system. This approach appeared to show considerable merit for some period of time. Shell Oil Company was sufficiently convinced of its feasibility to develop and test models and it was expected at the time of the contract modification that Shell would build a prototype. Also, it was anticipated that McDermott would have access to the technical data Shell used in developing their concept. However, as a result of a meeting with one of BIPM'S representatives, further effort on the Shell approach was abandoned for the following reasons:

1. It was learned that Shell had postponed further development work on the double arm system and the fabrication and testing of its prototype because of the many unresolved mechanical details which had not been sufficiently worked out or developed.

2. Recognizing the magnitude of Shell's own development effort on this approach, and without Shell's technical data, it was felt that for McDermott to initiate and develop the Shell concept suffici-

ently to firmly establish feasibility, a level of effort considerably beyond the scope of this contract, both in terms of time and manpower, would be required.

I. The preliminary design of Approaches 1B and 6A - Tanker alongside buoy, with submerged pipe arm, appeared to have the greatest potential for developing into a workable system. However, because of the complex geometry of the buoy-tanker mooring system, reliable force determination could not be made by using normal statics analysis. Therefore, McDermott developed a computer program for determining the relative motion and resultant forces between the tanker and the buoy in various sea spectra. McDermott felt that if the forces induced from motion were not excessive, a model test would be justified to verify the results obtained from the motion-force analysis.

Results of the motion-force analysis indicated that large forces would be developed and that an extremely large buoy would be required. Also, it later became apparent that the buoy-alongside-ship system would be difficult to install due to the large and heavy anchor chains and anchors required. This approach was mechanically complex, although not to

the extent that previous approaches had proved to be.

In spite of its apparent high cost, this concept was the only approach which satisfied the design criteria.

7.5 SUMMARY AND CONCLUSIONS

ERDL'S objective in modifying the contract was to improve the conventional type of mono-mooring system by eliminating part of the required hose and changing the type of mooring connection, while still satisfying strategic objectives originally specified in the first phase of the project.

Nine approaches were investigated. Seven of these approaches were abandoned due to either excessive mechanical complexity requiring development effort beyond the scope intended by the contract, or simply because they were not workable.

One approach, the Shell double arm configuration, was abandoned because even though Shell had invested large amounts of manpower and time in its development, it was not considered sufficiently feasible to develop a prototype.

The remaining approach, the buoy-alongside-ship, at first appeared to be workable and possessed many advantages over the other approaches, among which were the following:

7.5 SUMMARY AND CONCLUSIONS - Continued

A. The floating hose was eliminated.

B. The problem of the tanker overriding the buoy was eliminated.

C. This approach was most adaptable to self-mooring which would allow operation in much higher sea states.

D. It could be installed in a normal water depth.

E. It was not overly complicated.

It was found that this approach possessed the following disadvantages:

A. The clearance between the tanker and the anchor chain was minimal in the tanker overriding condition.

B. Excessive weight.

C. Excessive cost.

D. Very heavy mooring lines were required.

E. Complicated mooring geometry.

F. Special bitts would be required on the tanker to accommodate the full mooring load.

In conclusion, it was felt that to satisfy the Army's particular requirements listed in Exhibit B of the Purchase Description, none of the concepts investigated showed sufficient promise to justify further development or model testing. The original mono-mooring system developed by McDermott for ERDL is generally superior in terms of the Purchase Description.

VII. DESIGN - DEVELOPMENT OF A RIGID ARM CONNECTION BETWEEN THE TANKER AND THE BUOY

7.5 SUMMARY AND CONCLUSIONS - Continued

With further development, the various approaches investigated could probably overcome some of the inherent difficulties experienced in the present generation of Mono-Mooring Systems and operate more efficiently. However, these approaches could only offer maximum advantage in a permanent installation suitable for commercial use.

MAINTENANCE & INSPECTION MANUAL

MAINTENANCE AND INSPECTION
MANUAL

MONO-MOORING SYSTEM

FOR

U. S. ARMY

ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES

FORT BELVOIR, VIRGINIA

CONTRACT NO. DA-44-009-AMC-841(T)

J. RAY McDERMOTT & CO., INC.
NEW ORLEANS, LOUISIANA

1966

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SECTION 1

1.0 INTRODUCTION

This manual, required under USA-ERDL Contract No. DA-44-009-AMC-841(T), presents instructions, procedures and schedules for maintenance of the Mono-Mooring System, and is to be used in conjunction with manufacturers' instruction and maintenance manuals covering each component, system, or sub-system which is part of a specific installation.

SECTION 2

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.1 SUB-SYSTEMS

The buoy sub-systems should be inspected prior to each tanker mooring and as shown in the Maintenance and Lubrication Schedule in Section 3.0 of this manual.

2.1.1 Product Handling

Refer to McDermott Drawing No. USA-2971, Sheets 870 and 871.

The product-handling system should be checked for joint leakage, inoperative valves, resistance to rotation of the main product swivel and the overboard swivels, and operation of the overboard swivel-locking mechanism. The components of this system should be lubricated in accordance with Section 3.0 of this manual.

2.1.2 Fuel Oil

Refer to McDermott Drawing No. USA-2971, Sheet 868.

The fuel oil system should be checked at regular intervals and fuel added as necessary to insure an adequate supply for sustained engine operation during pretensioning of the anchor legs, swivel servicing, or other maintenance functions. The fuel level should not be allowed to go below the one-fourth full mark on the fuel tank gauge.

The fuel line contains a fuel dehydrator and fuel filter with replaceable elements. These

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.1 SUB-SYSTEMS

2.1.2 Fuel Oil - Continued

elements should be replaced as recommended by the equipment manufacturer, or at least twice a year. The fuel piping should be checked at least every three months for tightness, and any leaks in the system should be eliminated.

2.1.3 Bilge

Refer to McDermott Drawing No. USA-2971, Sheet 868.

The bilge system should be checked monthly. Each bilge sump should be inspected to insure unrestricted flow to pump suction screen. Sea water should be poured into the sumps to check operation of the pumps. An inspection of the piping and valves should be made for leakage and to insure that all valves are operable. Where there is leakage around valve stems they should be tightened or repacked.

2.1.4 Salt Water

Refer to McDermott Drawing No. USA-2971, Sheet 868.

The salt water system should be checked each month for leaks in hoses and system connections. Packing glands on valves and pumps should be tightened or repacked as required.

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.1 SUB-SYSTEMS -Continued

2.1.5 Hydraulic System

Refer to McDermott Drawing No. USA-2971, Sheet 861.

The hydraulic system should be checked prior to and immediately after each period of operation. Before using the system, the fluid level in the reservoir should be checked and fluid added as required. Every three months a sample should be taken from the bottom of the reservoir to determine the presence of any water. If water is in evidence, the system should be inspected to determine the possible source, and corrective measures should be taken. All valves should be inspected to insure operability. All piping should be inspected for leakage. Hydraulic hoses between control console and hydraulic winch should be carefully inspected prior to each period of operation and replaced when evidence of wear, fatigue, or aging are found.

2.1.6 Electrical System

Refer to McDermott Drawing No. USA-2971, Sheet 602.

The electrical system should be inspected every three months, or as required. The generator should be run to recharge lighting and power batteries every 14 days for a minimum period of four

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.1 SUB-SYSTEMS

2.1.6 Electrical System - Continued

hours. All battery cable connections should be checked for tightness or loss of conductivity due to corrosion. The general condition of batteries should be checked for physical deterioration and, if required, electrolyte should be added. All fuses and illumination equipment should be checked and replaced as required.

2.2 MECHANICAL COMPONENTS

The mechanical components of the buoy should be inspected and serviced in accordance with the recommendations in Section 3.0 of this manual.

2.2.1 Swivel

Refer to McDermott Drawing No. USA-2971, Sheet 875.

The main buoy product-handling swivel should be inspected prior to and immediately after each tanker loading operation. The swivel should at all times rotate freely without binding or leaking.

The swivel is equipped with lubricating fittings and should be lubricated monthly with a suitable heavy-duty roller bearing grease as outlined in Section 3.0 of this manual. After a period of one year in service, the swivel should be partially disassembled by removing the bearing

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.2 MECHANICAL COMPONENTS - Continued

2.2.1 Swivel - Continued

cap to allow inspection of seal rings and seating sealing surfaces on the lower seal body, floating seal, top-bearing retainer and seal sleeve. Any of these parts showing wear should be repaired or replaced.

At the end of three years of service, it is recommended that the entire swivel be removed from the buoy and taken to an adequately equipped machine repair shop. A complete disassembly and inspection should be effected. Worn parts should be repaired or replaced and the swivel carefully reassembled. After reassembly, the swivel should be tested for leakage and freedom of rotation.

CAUTION:

Under no circumstances should the entire swivel be disassembled while on the buoy. The components of this assembly are machined to close tolerances, and forcing or damage to any portion of these may cause leakage or render the swivel inoperative. Both roller bearings are press-fitted into the housings, and extreme care should be exercised in their removal and reinstallation.

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.2 MECHANICAL COMPONENTS - Continued

2.2.2 Diesel Engine

The diesel engine should be maintained in accordance with the manufacturer's recommendations. Lubricating oil and filter cartridge should be changed after the operating period recommended by the engine manufacturer, or at least twice a year. The fresh water system should be kept filled at all times, and anti-freeze should be installed for low-temperature operation as recommended by the manufacturer. The exhaust system should be checked to insure that no exhaust gases escape into the engine compartment. The engine starter and generator should be serviced as recommended by the manufacturer.

2.2.3 Winches

The hydraulic winch should be lubricated prior to each operation and at least every three months. All grease fittings should be filled with a lubricant suitable for the temperature and service conditions under which the system is operating. The gear box should be filled to the proper level with suitable lubricating oil.

Once each year or whenever excessive water is detected, the gear box should be drained and refilled.

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.2 MECHANICAL COMPONENTS

2.2.3 Winches - Continued

The hand winch should have all exposed gearing coated monthly with grease, and all lubricating fittings should be kept filled with a suitable lubricant. An operational check should be performed monthly. Once each year all grease should be cleaned off the winch, a through inspection made for wear or deterioration, and repairs made wherever necessary.

2.2.4 Chain Stoppers

Refer to McDermott Drawing No. USA-2971, Sheet 888.

After the first four mooring operations, and every three months thereafter, the chain stoppers should be visually inspected by a diver for wear and distortion. If a stopper does not move freely or if excessive wear is detected, the stopper should be removed and taken to a machine repair shop for reconditioning.

2.2.5 Ventilation Cowls and Fans

The ventilation system should be checked monthly to insure that there are no sticking solenoids or locked fan motors. The ventilation system should be in operation at all time when the engine is running.

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.2 MECHANICAL COMPONENTS - Continued

2.2.6 Bogie Wheels

Refer to McDermott Drawing No. USA-2971, Sheets 883 and 886.

The bogie wheels of the rotating deck should be visually inspected prior to each tanker mooring to insure free movement of all components. All lubrication fittings should be filled monthly with a suitable lubricant. Once a year, a physical inspection should be made, and parts or assemblies should be replaced as required.

2.3 MOORING SYSTEM

Refer to McDermott Drawing No. USA-2971, Sheets 825 and 827.

The mooring system should be visually inspected for wear or damage before each mooring, with particular attention being paid to the nylon and wire ropes.

2.3.1 Nylon Ropes

The initial length of the nylon ropes should be measured before installation and should be re-measured and inspected at three-month intervals. The nylon ropes should be replaced when the elongation of either rope exceeds thirty (30%) percent of the original length of if fusing of strands or significant chafing has occured. Unless in-service experience indicates longer life is feasible, the nylon ropes and thimble portion of the mooring system shall be replaced annually.

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.3 MOORING SYSTEM - Continued

2.3.2 Wire Ropes

The wire rope tail lines and bitt lines shall be visually inspected before each mooring for excessive wear, kinks, corrosion, or damage and shall be replaced before their strength is reduced to a dangerously low value.

2.3.3 Chain Ends

Refer to McDermott Drawing No. USA-2971, Sheet 827.

Before each mooring operation, the chain ends and their related fittings, shackles, swivels, sister plates, Senhouse slip hooks, etc. shall be visually inspected for wear, corrosion and significant deterioration. They shall be replaced when significant deterioration has occured or when the mean diameter has been reduced by one-fourth (1/4") inch due to wear or corrosion.

The grease-packed box swivel and other chain fittings shall be thoroughly lubricated monthly.

2.3.4 Floats

The nylon rope PVC floats and the tag buoys should be visually inspected periodically and replaced if damaged substantially or if loss of buoyancy has occured for any reason.

2.0 MAINTENANCE AND INSPECTION PROCEDURES - Continued

2.4 ANCHOR SYSTEM

Refer to McDermott Drawing No. USA-2971, Sheets 825 and 826.

2.4.1 Anchor Leg Tension

The tension in all eight anchor legs should be checked after the first four mooring operations and every three months thereafter. If a tanker rides out a period of rough weather while moored to the buoy, the tension in the anchor legs should be measured immediately after the tanker's departure. Tension should be checked by measuring the angle between each anchor leg and the buoy fender skirt. If this angle is found to differ from its specified value, tension shall be corrected immediately.

2.4.2 Anchor Chain

At the same time the anchor leg tension is checked, the anchor chain immediately below and just entering the chain stopper should be visually checked by a diver for wear and distortion. If the chain's diameter is decreased by one-fourth (1/4")inch or more, or if significant distortion is detected, the chain should be removed from the chain stopper, hauled aboard a barge, cut back well below the damaged or worn portion, and a new length of chain welded or shackled on. The chain should then be passed through the stopper and re-tensioned to the correct value.

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.4 ANCHOR SYSTEM - Continued

2.4.2 Anchor Chain

Inspection of the entire anchor legs should be made every six months to determine corrosion rate and condition of chain at sea bed. When chain shows one-fourth (1/4") inch or more loss of diameter or is considered unsafe by the inspector, corrective measures should be undertaken immediately.

2.5 HOSE SYSTEM

Refer to McDermott Drawing No. USA-2971, Sheet 840.

The hoses, both floating and submarine, will probably be of different manufacture for each installation; therefore, recommendations are for general inspection and maintenance only. Complete specific maintenance data should be obtained from the manufacturer of the hose supplied, and since it is one of the most critical components of the facility, regular inspection and maintenance must be performed.

2.5.1 Floating Hoses

Floating hoses should be visually inspected regularly for abrasion, kinks, ballooning, or evidence of leakage. Sections which show evidence of unduly high abrasion or of kinking, ballooning, or leaking in the rubber portion should be replaced.

Should leakage occur at a flange joint, efforts should be made first to tighten the bolts

2.5 HOSE SYSTEM

2.5.1 Floating Hoses - Continued

or to install new bolts and gaskets. If leakage continues, the hose section will have to be removed and sent to a repair shop for flange refacing.

At the end of one year of service, the end sections of hose adjacent to the buoy should be disconnected and taken to a site where a careful inspection can be made. If visual damage of the type mentioned above is evident, a hydrostatic test to working pressures should be conducted. Any hose section which fails to meet this test should be replaced.

The end sections adjacent to the buoy should be removed every six months and reinstalled with the ends reversed. The hose floats should be inspected regularly and replaced if there is evidence of excessive damage or loss of buoyancy.

Tag lines and end marker buoys should be checked for soundness and replaced when they are damaged or considered unsafe.

2.5.2 Submarine Hoses

Submarine hoses should be visually inspected by divers for the same faults outlined in Section 2.5.1, of this manual.

2.0 MAINTENANCE AND INSPECTION PROCEDURES

2.5 HOSE SYSTEM

2.5.2 Submarine Hoses - Continued

A hydrostatic test to working pressures should be conducted annually on the entire submarine hose system. Where practical the hose should be removed from the system for the performance of this test.

The configuration of the hose should be checked to insure its free form into the "lazy S" pattern. If the floats are losing buoyancy or require relocation to maintain this configuration, corrective measures should be taken.

2.6 AIDS TO NAVIGATION SYSTEM

The navigational aids package should be inspected yearly and bulbs replaced in the obstruction lights as required. Batteries used for this package should be replaced after being activated and in service for 500 consecutive days or as required. The fog signal should have its drive unit replaced when it becomes inoperative or the sound signal become erratic.

2.7 LIFESAVING AND FIREFIGHTING EQUIPMENT

2.7.1 Lifesaving Equipment

All life vests and ring buoys on the buoy shall be visually inspected at three-month intervals to insure that they are in proper condition and that the correct number are aboard.

2.7 LIFESAVING AND FIREFIGHTING EQUIPMENT - Continued

2.7.2 Firefighting Equipment

All fire extinguishers shall be inspected and tagged in accordance with the manufacturer's recommendations.

2.8 BUOY HULL

Refer to McDermott Drawing No. USA-2971, Sheet 001.

The buoy hull and structural components should be visually inspected annually for damage or deterioration. If defects are noted, corrective measures should be employed immediately to prevent total failure and possible loss of the buoy.

Every three years, the buoy should be removed to a shipyard or suitable repair facility where a close physical inspection of the hull and cathodic protection system can be made. Repairs or replacement of all worn or defective components should be accomplished, and the entire buoy painted or touched-up as required.

SECTION 3

3.0 MAINTENANCE AND LUBRICATION SCHEDULE

Section	Item	Lubricate	Adjust	Gen Fre
2.1	SUB-SYSTEMS			
2.1.1	Product Handling System	Monthly	If Req'd	36
2.1.6	Electrical System	--	--	
2.2	MECHANICAL COMPONENTS			
2.2.1	Swivel	Monthly	--	36
2.2.3	Winches:			
	Hydraulic Winch	Prior to Operating & Quarterly	As Req'd	As
	Hand Winch	Same as Air Winch	As Req'd	12
2.2.4	Chain Stoppers	Sea Water Lub.	--	36
2.2.6	Bogie Wheels	Monthly	--	36
2.3	MOORING SYSTEM			
2.3.1	Nylon Ropes	--	--	12
2.3.2	Wire Ropes	As Necessary	--	12
2.3.3	Chain Ends	Monthly	--	12
2.3.4	Floats	--	--	12
2.4	ANCHOR SYSTEM	--	Quarterly	6
2.5	HOSE SYSTEM	--	As Req'd	12
2.6	AIDS TO NAVIGATION SYSTEM			
	Obstruction Light	--	As Req'd	12
	Batteries	--	--	12
	Fog Signal	--	--	12
2.7	LIFESAVING & FIREFIGHTING EQUIPMENT	--	--	3
2.8	BUOY HULL	--	--	36

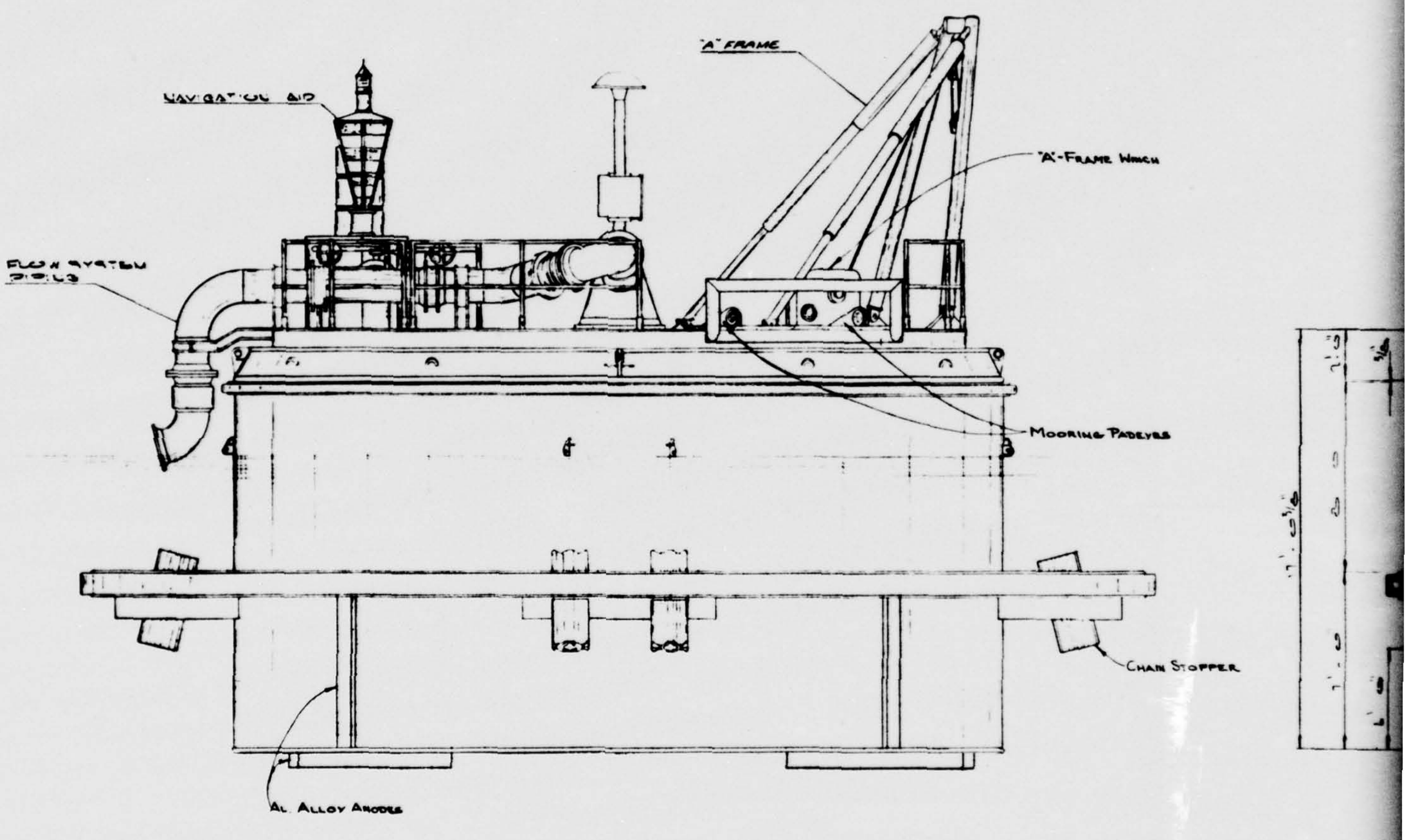
djust	Gen. Overhaul Frequency	Remarks
f Req'd	36 Months	See Section 2.1 for inspection schedules
--	--	Run generator and recharge batteries every 14 days
--	36 Months	See Section 2.2.1 for 12 months and 36 months inspection
s Req'd	As Req'd	See Section 2.2.3 for lubrication
s Req'd	12 Months	See Section 2.2.3 for lubrication
--	36 Months	See Section 2.2.4 for inspection schedules
--	36 Months	See Section 2.2.6 for inspection periods and lubrication
--	12 Months	See Section 2.3.1 for inspection schedules
--	12 Months	See Section 2.3.2 for inspection schedules
--	12 Months	See Section 2.3.3 for inspection schedules and lubrication
--	12 Months	Replace damaged or non-functioning materials as observed
uarterly	6 Months	See Section 2.4.1 for tensioning and replacing
s Req'd	12 Months	See Sections 2.5.1 & 2.5.2 and manufacturer's recommendations
s Req'd	12 Months	See Section 2.6 for general maintenance instructions
--	12 Months	Replace after 500 consecutive days operation
--	12 Months	Replace drive unit when inoperative or sound is erratic.
--	3 Months	Check and recharge extinguishers every 6 months or after using
--	36 Months	See Section 2.8 for inspection periods

SECTION 4

4.0 LIST OF DRAWINGS

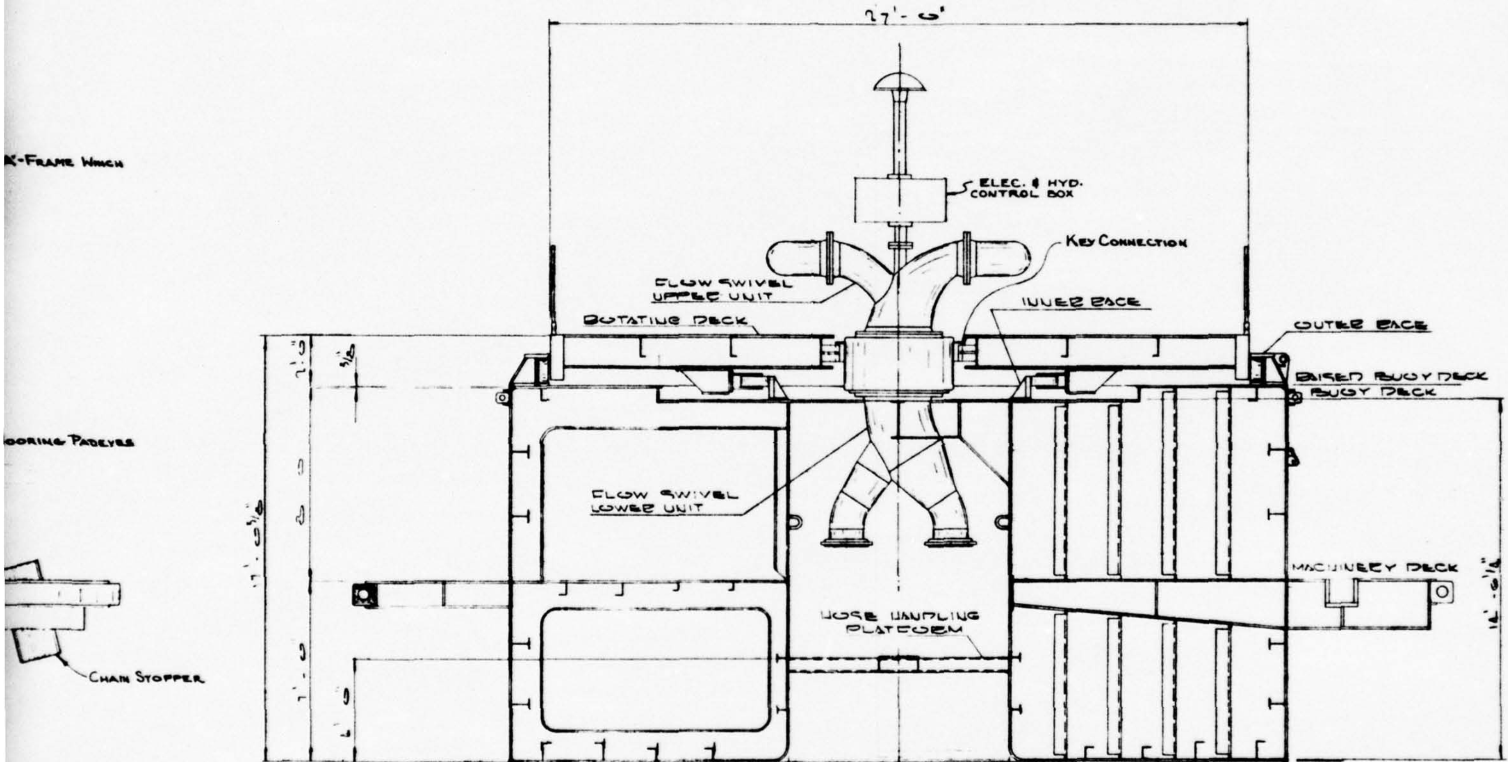
Drawing No.	Sheet	Title
USA-2971	001	Outboard Profile - Sections thru Buoy
USA-2971	002	Plan at Top of Rotating Table
USA-2971	602	Wiring Diagram
USA-2971	825	Mooring and Anchor System
USA-2971	826	Anchor System Details
USA-2971	827	Mooring System
USA-2971	840	Hose Assembly
USA-2971	861	Buoy Winch - Hyd. System Schematic
USA-2971	868	Diesel Engine Piping Schematics
USA-2971	870	Flow System Piping Arrangement
USA-2971	871	Flow Unit Swivel Assembly
USA-2971	875	Flow Swivel Assembly
USA-2971	883	Assembly and Details - Inner Race Bogie Wheels
USA-2971	886	Assembly and Details - Outer Race Bogie Wheels
USA-2971	888	Assembly - Chain Stoppers

/



OUTBOARD PROFILE

DESIGN	STRUCT	PIPING	ELEC	MK	BY	REVISIONS	DATE	APP	DESIGN	STRUCT	PIPING	ELEC	MK	BY	REVISIONS	DATE	APP	DESIGN	STRUCT	PIPING



SECTION THRU BUOY SHOWING TYP.
WEB FRAME & BULKHEAD FRAMING

REVISIONS	DATE	APP.	DESIGN	STRUCT	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 700
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: GCLee
J. RAY McDERMOTT & CO., INC.
DATE: 1-28-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT	GCL	1-27-66
STRUCTURAL	TCA	10-20-66
PROCESS		
MECHANICAL		
ELECTRICAL		
INSTRUMENT.		
FAB. CHECK	GA	9-9-66
PROP. CHECK		

MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH
& DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

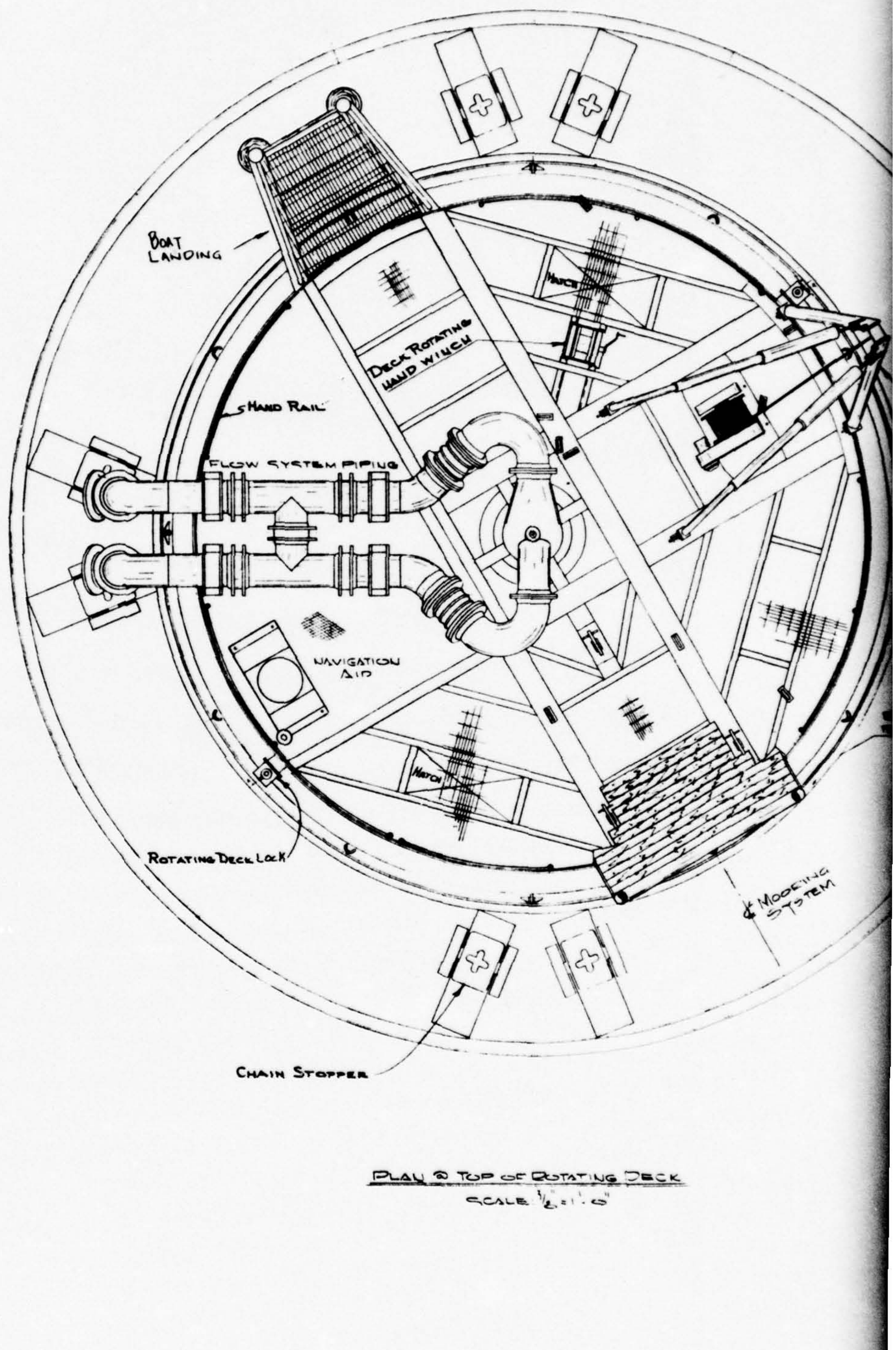
J. RAY McDERMOTT & CO., INC.
ENGINEERS — CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
ROSS	3/16" = 1'-0"	5-26-65	USA 2971
FABRICATORS JOB NO.	56017	J. RAY McDERMOTT JOB NO.	SHEET NO. 001

OUTBOARD PROFILE - SECT THRU BUOY

2

1



PLAN @ TOP OF ROTATING DECK
SCALE 1/8" = 1'-0"

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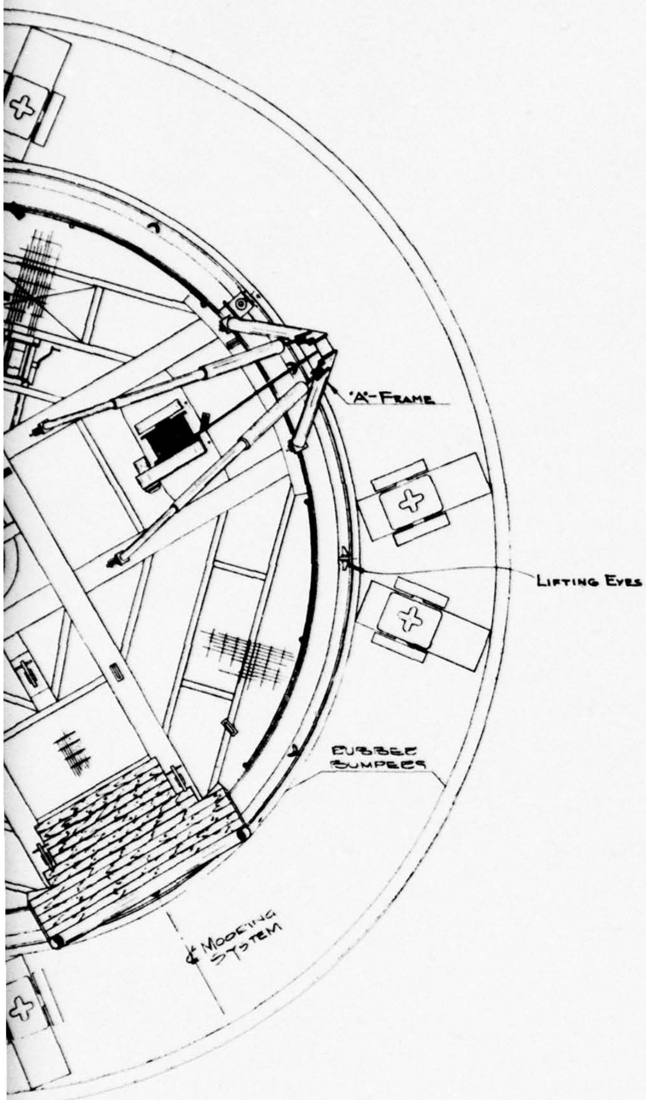

...TING DECK
...'-0"

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STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 786
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DATE 1-28-66

ENGINEERS APPROVAL	BY	DATE
PROJECT	RC	12-6
STRUCTURAL	J.C.A.	12-28-65
PROCESS		
MECHANICAL		
ELECTRICAL		
INSTRUMENT		
FAB. CHECK		9-7-65
PROP. CHECK		

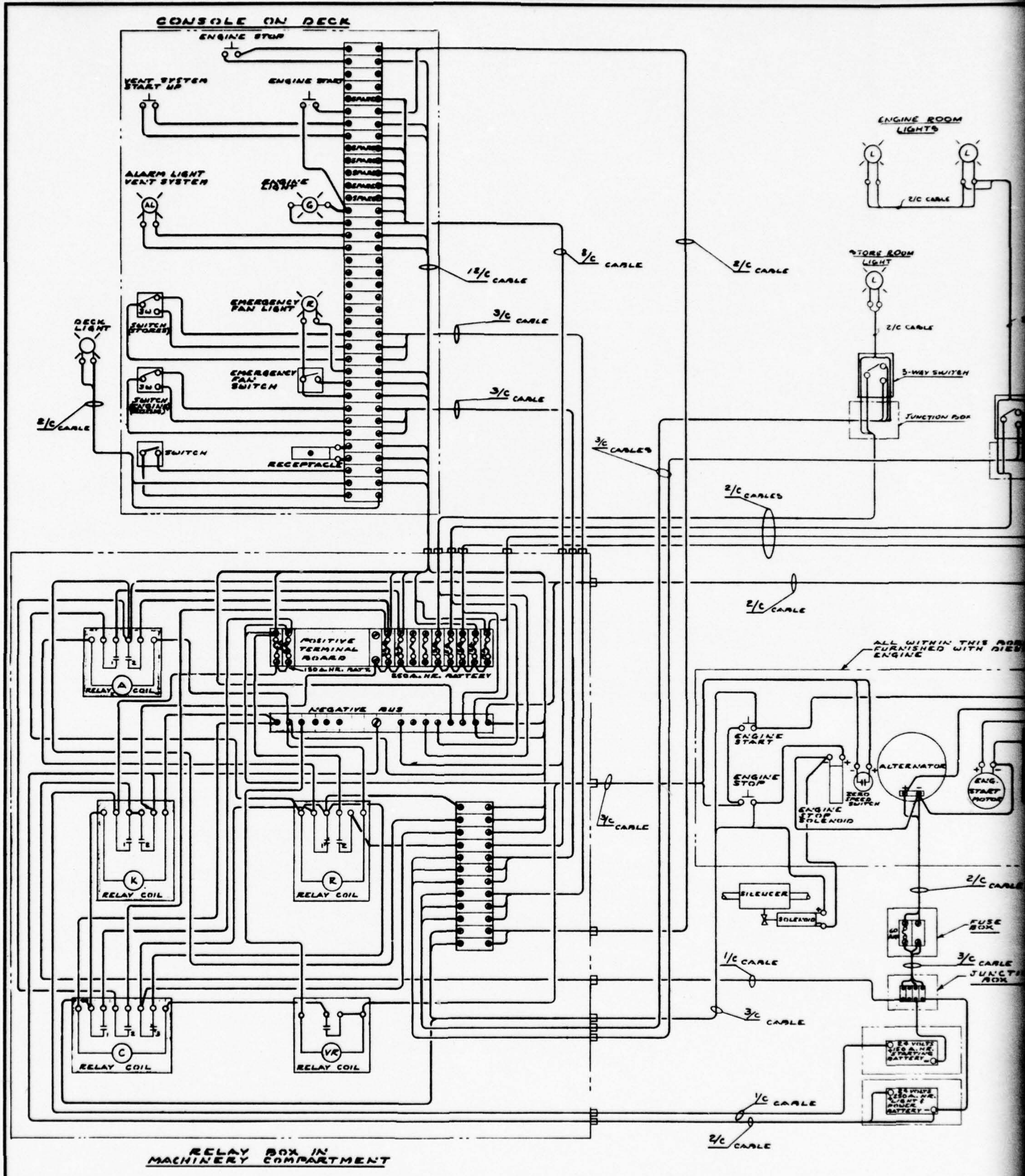
MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH
& DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY Mc DERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
ROSS	NOTED	5-21-65	USA 2971
FABRICATORS JOB NO.		J. RAY McDERMOTT JOB NO.	SHEET NO.
	56017		002

PLAN @ TOP OF ROTATING DECK



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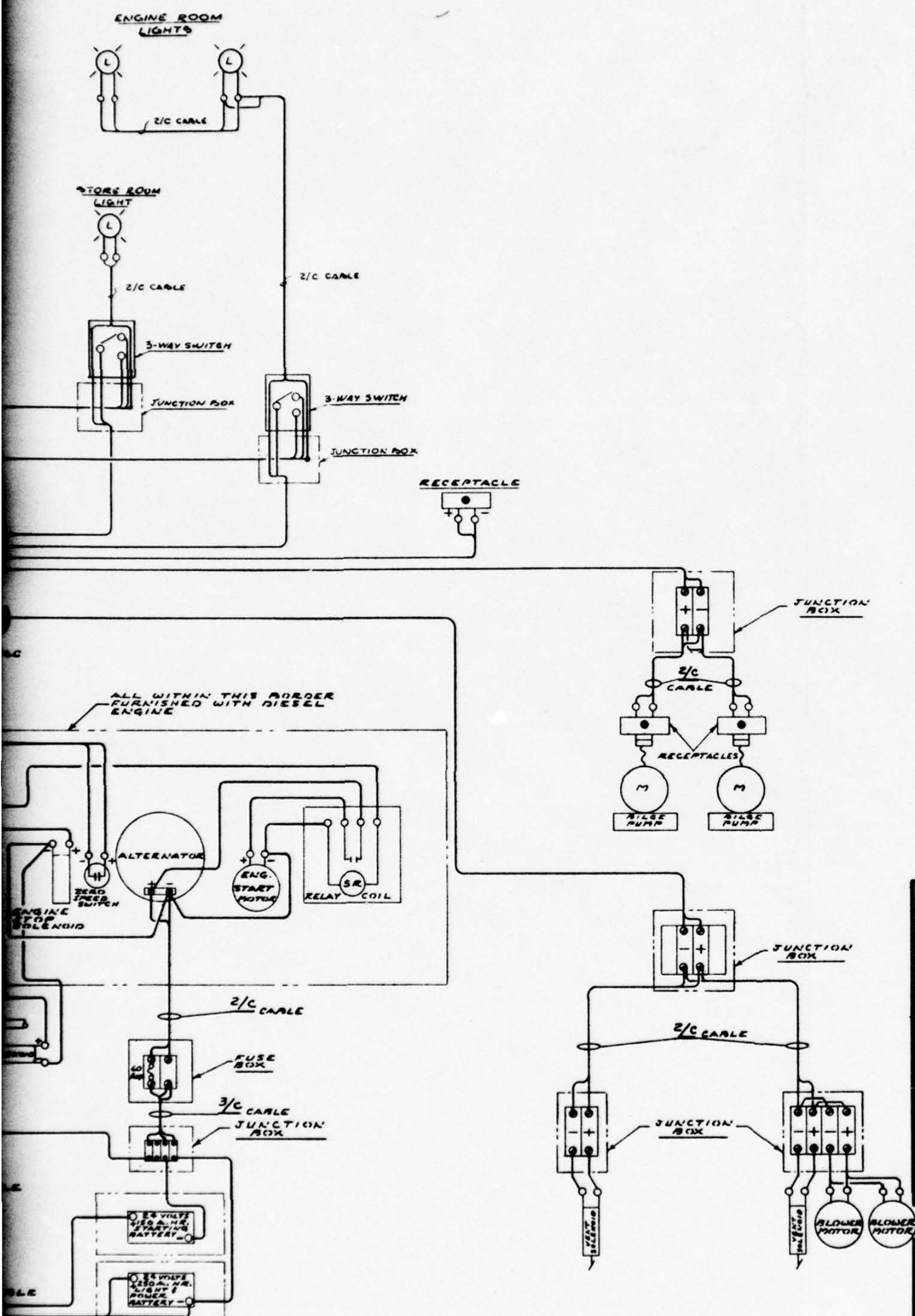


REFERENCE DRAWINGS

SHT. No.	TITLE
601	ELECTRICAL SCHEMATIC DIAGRAM
603	ELECTRICAL ARRANGEMENT OF MACH. & STORAGE COMPARTMENTS
604	ELECTRICAL ARRANGEMENT ON CONSOLE
605	SECTIONS, ELEVATIONS, & DETAILS

REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 166
REGISTERED PROFESSIONAL ENGINEER
IN ENGINEERING

APPROVED: GCLee
J. RAY McDERMOTT & CO., INC.
DATE: 1-28-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT		
STRUCTURAL		
PROCESS		
MECHANICAL		
ELECTRICAL		1-20-66
INSTRUMENT		
FAB. CHECK		1-27-66
PROOF CHECK		

MONO-MOORING SYSTEM

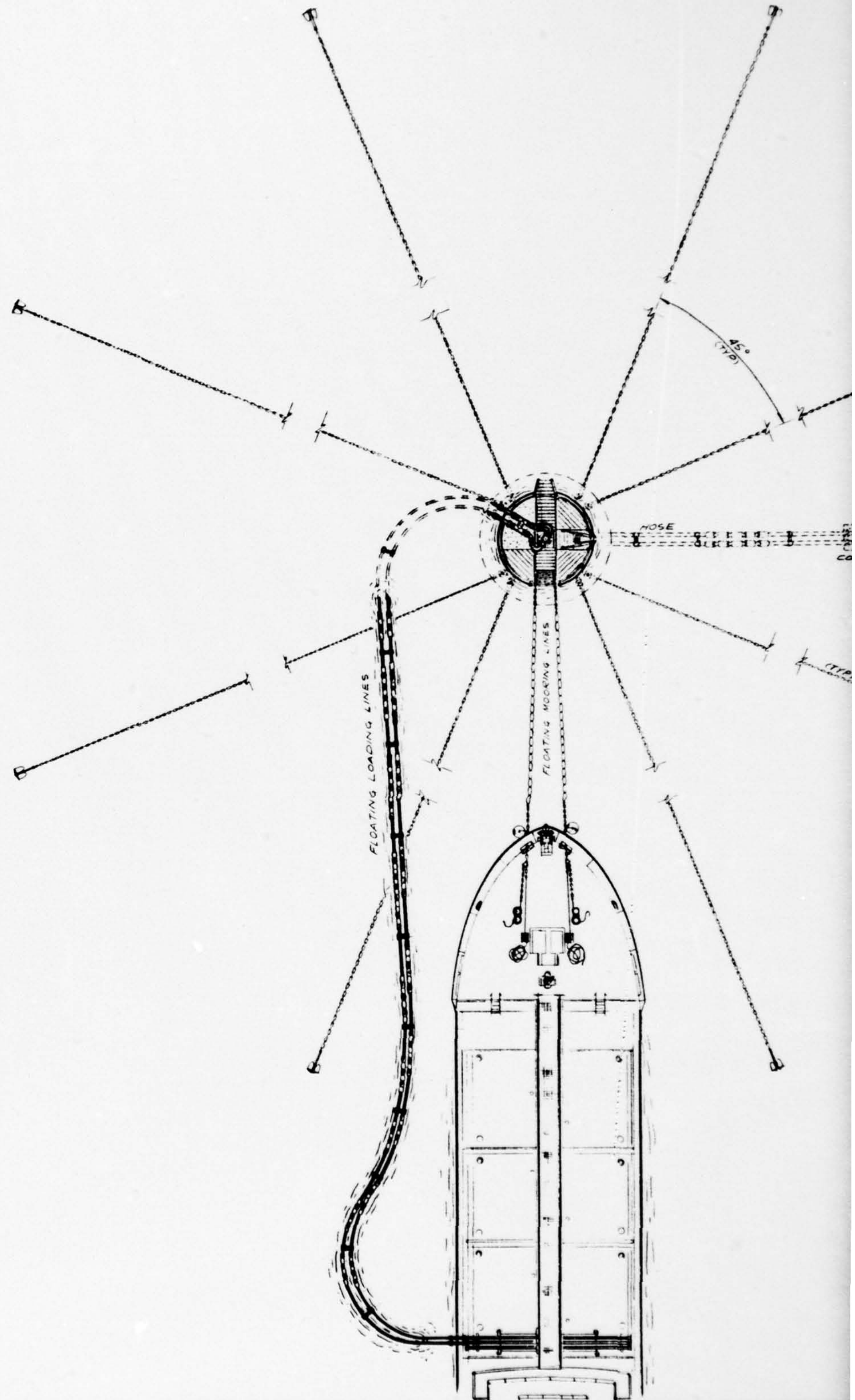
FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
G. BABIN	NONE	10-7-65	USA-2971
FABRICATORS JOB NO.		J. RAY McDERMOTT JOB NO.	SHEET NO.
		56017	602

WIRING DIAGRAM

1



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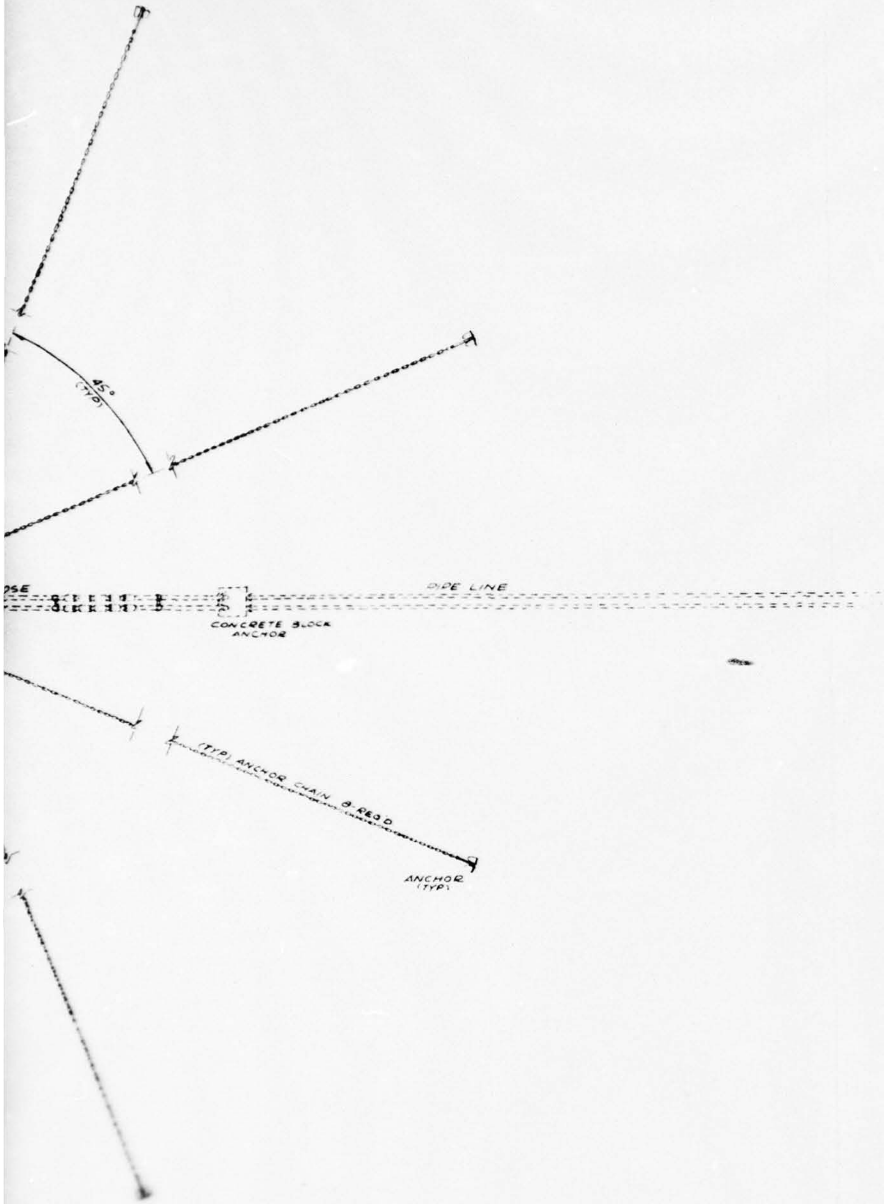
2



STATE OF LOUISIANA
GRIFF C. LEE
REG. No 706
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: G C Lee
J. RAY McDERMOTT & CO., INC.
DATE: 7-28-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT	GKS	1-28-66
STRUCTURAL	T.C.A.	10-25-66
PROCESS		
MECHANICAL		
ELECTRICAL		
INSTRUMENT		
FAB. CHECK		
PROP. CHECK		

MONO-MOORING SYSTEM

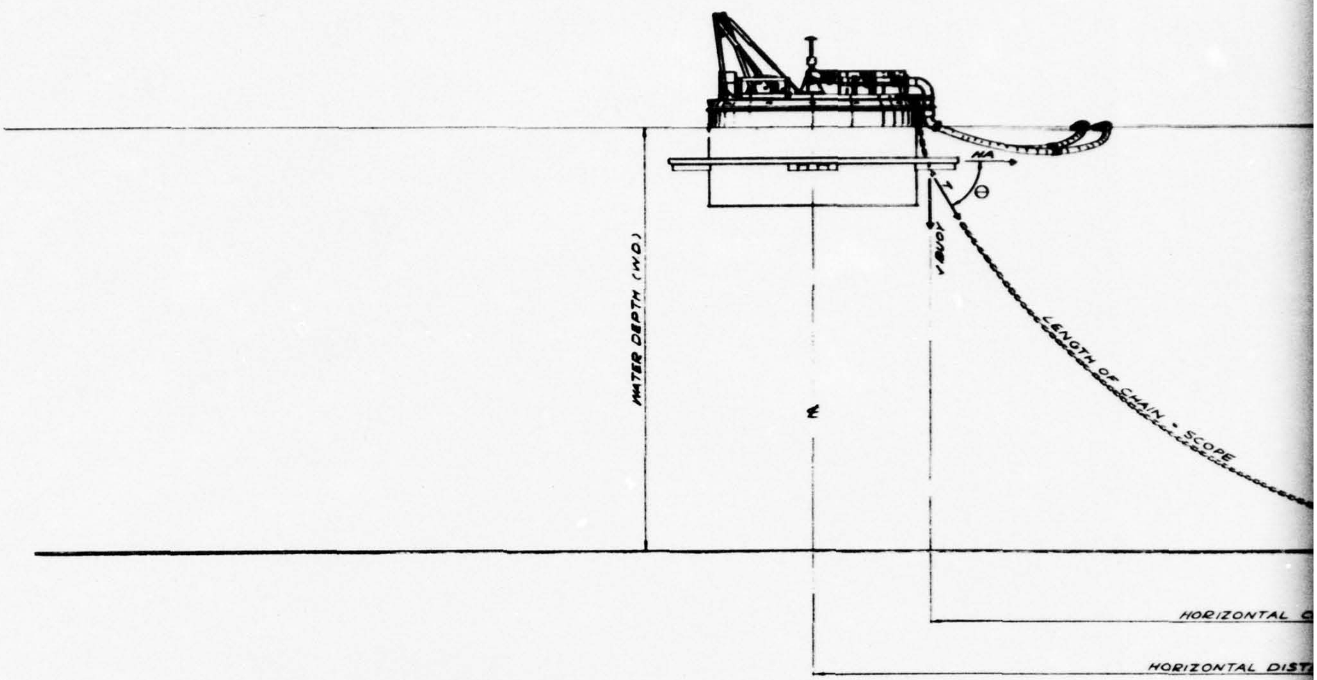
FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS — CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
S. DELAUNE	NONE	8-25-66	U.S.A.-2971
FABRICATORS JOB NO.		J. RAY McDERMOTT JOB NO.	SHEET NO.
	56017		825

MOORING & ANCHOR SYSTEM

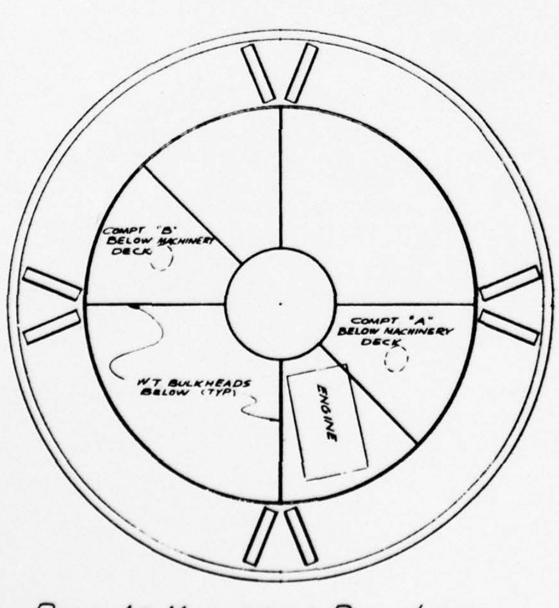
1



INSTALLATION

WATER DEPTH W.D. (FEET)	PRE-LOAD T (KIPS)	HORIZONTAL HA (KIPS)	VERITICAL V BUOY (KIPS)	ANGLE θ (DEGREES)
50	8.8	5.28	7.05	53
60	10.3	6.0	8.4	54
70	12.8	8.0	10.0	51
80	16.0	10.0	12.5	51
90	18.6	12.0	13.8	50
100	21.4	13.5	15.7	49°
110	24.1	16.0	18.0	48.4
120	26.8	18.0	19.8	47.7
130	29.4	20.0	21.6	47.2
140	30.3	19.5	23.0	49.7°
150	30.3	19.5	23.0	49.7°

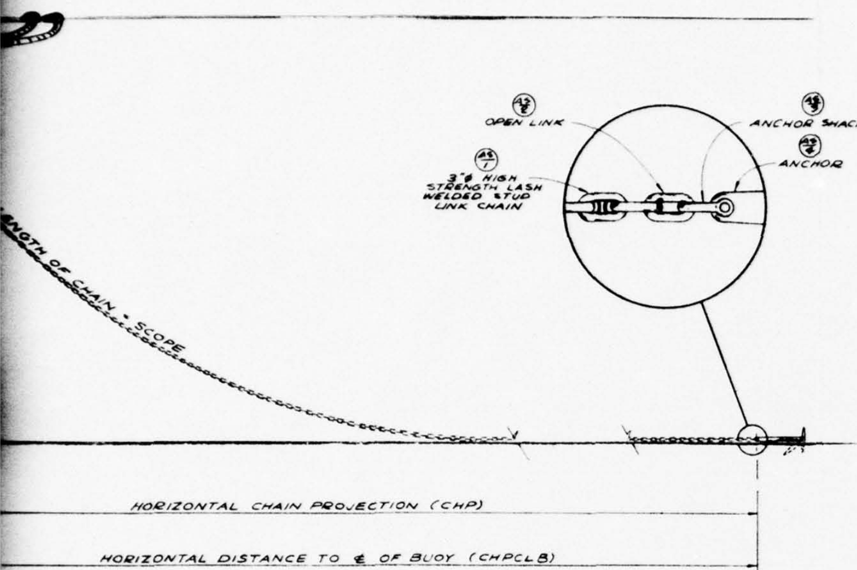
EXTRA CHAIN IS PROPORTIONED AS FOLLOW
50 FEET ANCHOR DRAG
50 FEET ANCHOR PLACEMENT ALLOWANC
20 FEET INSTALLATION ALLOWANCE



PLAN AT MACHINERY DECK LEVEL

DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT

2



BILL OF MATERIAL

FIND NO	DWG NO	QTY.	NOMENCLATURE	SPEC.	MAT'L
AS-1	926	8	ANCHOR LEGS - 3"⌀ HIGH STRENGTH FLASH WELDED STUD LINK CHAIN (SEE INSTALLATION CHART FOR SCOPE)	MIL-C-21185 (SEE NOTE 1)	STEEL
AS-2	926	8	OPEN LINK FOR 3"⌀ H.S. CHAIN	MIL-C-18295B (SEE NOTE 2)	STEEL
AS-3	926	8	#3 ANCHOR SHACKLE	MIL-C-18295B (SEE NOTE 2)	STEEL
AS-4	926	8	15,000 POUND BUDOCKS STATO MOORING ANCHOR	YARDS & DOCKS DWGS. 813603 THRU 813606	STEEL

INSTALLATION TABLE

RIZONTAL A (KIPS)	VERITICAL V BUOY (KIPS)	ANGLE θ (DEGREES)	SCOPE* (FEET)	CHP (FEET)	CHPBCL (FEET)	BALLAST COMPTS. A&B	
5.28	7.05	53	730	669	686	YES	
6.0	8.4	54	790	725	742	YES	
8.0	10.0	51	860	792	809	YES	
10.0	12.5	51	900	832	849	YES	
12.0	13.8	50	940	868	885	YES	
13.5	15.7	49°	975	900	917	NO	
16.0	18.0	48.4	1000	923	940	NO	
18.0	19.8	47.7	1020	940	957	NO	
20.0	21.6	47.2	1040	958	975	NO	
19.5	23.0	49.7°	1050	964	981	NO	
19.5	23.0	49.7°	1060	968	985	NO	

OPORTIONED AS FOLLOWS:
R DRAG
R PLACEMENT ALLOWANCE
LLATION ALLOWANCE

REFERENCE DRAWINGS

SHT NO	TITLE
825	MOORING & ANCHOR SYSTEM

NOTES:

1. HIGH STRENGTH FLASH WELDED STUD LINK CHAIN COMPLIES WITH MIL-C-21185 EXCEPT AS NOTED IN ANCHOR SYSTEM SPECIFICATIONS.
2. CHAIN FITTINGS COMPLY WITH MIL-C-18295B EXCEPT AS NOTED IN ANCHOR SYSTEM SPECIFICATIONS.

	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
C. LEE
REG. No. 706
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: G. C. Lee
J. RAY McDERMOTT & CO. INC.
DATE: 1-28-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT	JRS	1-28-66
STRUCTURAL	J.C.A.	10-28-65
PROCESS		
MECHANICAL		
ELECTRICAL		
INSTRUMENT		
FAB. CHECK		
PROP. CHECK		

MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH
& DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

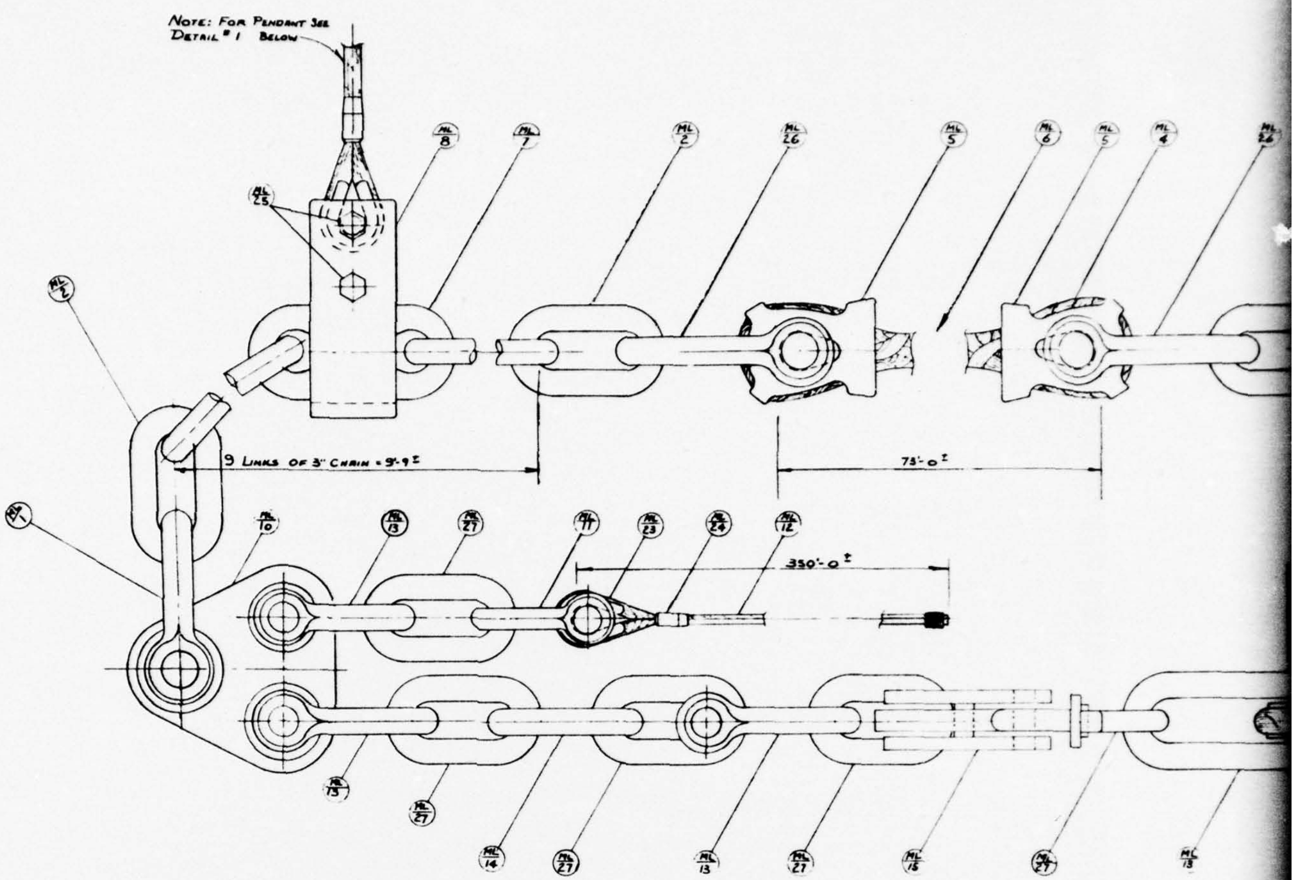
J. RAY Mc DERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
S. DELAUNE	NONE	8-26-65	USA-2971
FABRICATORS JOB NO.	56017	J. RAY McDERMOTT JOB NO.	SHEET NO. 826

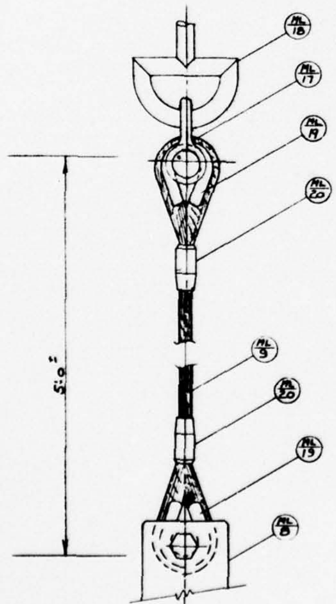
ANCHOR SYSTEM DETAIL

△

1



MOORING LINE ~ (2) REQD.

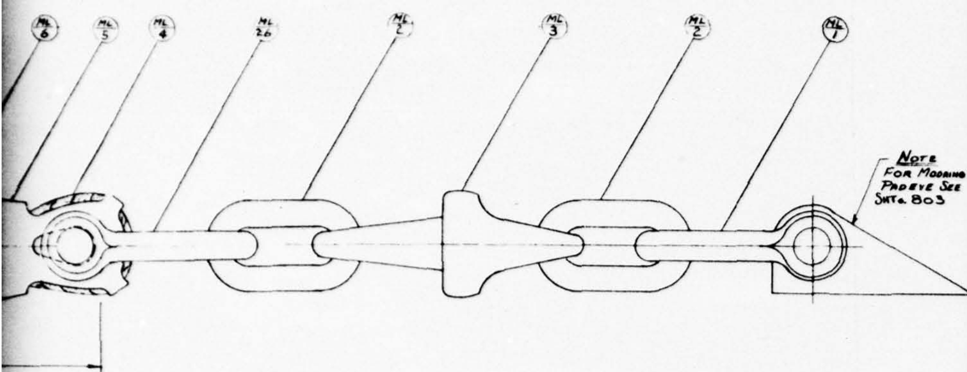


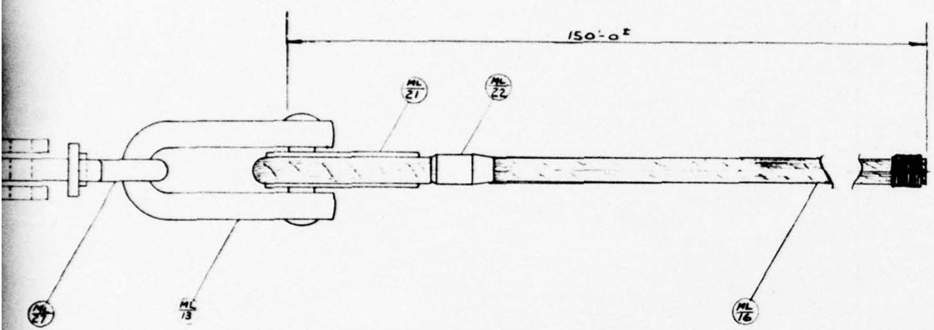
PENDANT DETAIL

DETAIL #1

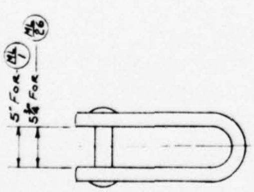
DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN

2





INE ~ (2) REQD.



Ref. 3½"ø Round Pin Anchor Shackle
Detail #2

Bill Of Material (Qty. Shown For Two (2) Lines)

Find Nr.	Dwg. Nr.	Qty.	Nomenclature	Spec.	Mat'l.
ML-1	827	4	3½"ø Round Pin Anchor Shackle, See Det #2 (Baldt)	MIL-C-18295B	Stl.
ML-2	"	8	Open Link For 3"ø Chain (Baldt)	-do-	"
ML-3	"	2	Grease Packed Box Swivel For 3"ø Chain (Baldt)	-do-	"
ML-4	"	2	80'-0 of 12" Circum. Nylon Rope, 8 Braid Plait, Kink Proof	MIL-R-17343C (See Note #1)	Nylon
ML-5	"	4	Plastic Rope Thimble For 12" Circum. Rope (Newco)	MIL-T-23326 (See Note #2)	Bronze Alloy
ML-6	"	*	Closed Cell One Piece PVC Floats.		PVC
ML-7	"	2	(9) Links of 3" Hi-Strength, Flash Welded, Stud Link Chain	MIL-C-21186	Stl.
ML-8	828	2	Bar-U-Bolt (Galvanized)	As Detailed	A-36 Stl.
ML-9	827	2	¾"ø, 6x19 I.P.S. Wire Rope w/ I.W.R.C. (8'-0 Lg.) (Galvanized)	Fed. RR-W-410A	Stl.
ML-10	828	2	Sister Plate	As Detailed	A36 Stl.
ML-11	827	2	2½"ø Round Pin Anchor Shackle (Baldt)	MIL-C-18295B	Stl.
ML-12	"	2	1⅝"ø, 6x19, Extra I.P.S. Wire Rope w/ I.W.R.C. (365'-0 Lg.)	Fed. RR-W-410A	"
ML-13	"	8	3"ø Round Pin Anchor Shackle (Baldt)	MIL-C-18295B	"
ML-14	"	2	Link of 2¾" Hi-Strength, Flash Welded, Stud Link Chain (Baldt)	MIL-C-18295	"
ML-15	"	2	Senhouse Slip Hook For 2¾ Chain		"
ML-16	"	2	2"ø, 6x19 Extra I.P.S. Wire Rope w/ I.W.R.C. (155'-0 Lg.)	Fed. RR-W-410A	"
ML-17	"	2	1½" Safety Type Anchor Shackle (Crosby-Laughlin)	MIL-C-18295 B	Stl
ML-18	828	2	Spherical PVC Material Buoy	See Spec. As Detailed	PVC
ML-19	827	4	Extra Heavy Wire Rope Thimble For ¾"ø W.R. (Crosby-Laughlin) Galv.		Stl.
ML-20	"	4	Swaged Sleeve For ¾"ø Wire Rope (Galvanized)		"
ML-21	"	2	Extra Heavy Wire Rope Thimble For 2"ø W.R. (Crosby-Laughlin)		"
ML-22	"	2	Swaged Sleeve For 2"ø Wire Rope (Galvanized)		"
ML-23	"	2	Extra Heavy Wire Rope Thimble For 1⅝"ø W.R. (Crosby-Laughlin) Ga.		"
ML-24	"	2	Swaged Sleeve For 1⅝"ø Wire Rope (Galvanized)		"
ML-25	"	4	Bolt, Reg. Hex. Hd. 1"x6" Lg. w/ Nut (Galvanized)	ASTM-A307	Stl.
ML-26	"	4	3½"ø Round Pin Anchor Shackle See Det. #2 (Baldt)	MIL-C-18295B	Stl.
ML-27	"	10	Open Link For 2¾"ø Chain (Baldt)	MIL-C-18295 B	Stl.

Reference Drawings

Sht. Nr.	Title
803	Rotating Deck Framing Plan
828	Mooring System Details #1

Notes

(*) Ref. Closed Cell One Piece PVC Floats. Internal Dia. 10% Greater Than Nylon Rope. Quantity To Suit, As Required To Fill Length Of Nylon Rope.

1. Nylon Rope Complies With MIL-R-17343C With Exceptions Noted In Mooring System Specifications.
2. Plastic Rope Thimble To Conform To MIL-T-23326 With Exceptions Noted In Mooring System Specification.

...sions	Date	App.	Design	Struct.	Piping	Elec.	Mk	By	Revisions	Date	App.

State of Louisiana
Griff C. Lee
Reg. No. 786
Registered Professional Engineer in Civil Engineering

Approved: G C Lee
J. Ray McDermott & Co., Inc.
Date: 1-28-66

Engineers Approval

	By	Date
Project	[illegible]	1-27-66
Structural	S.C.B.	10-28-65
Process		
Mechanical		
Electrical		
Instrument		
Fab. Check	[illegible]	9-9-66
Prop. Check		

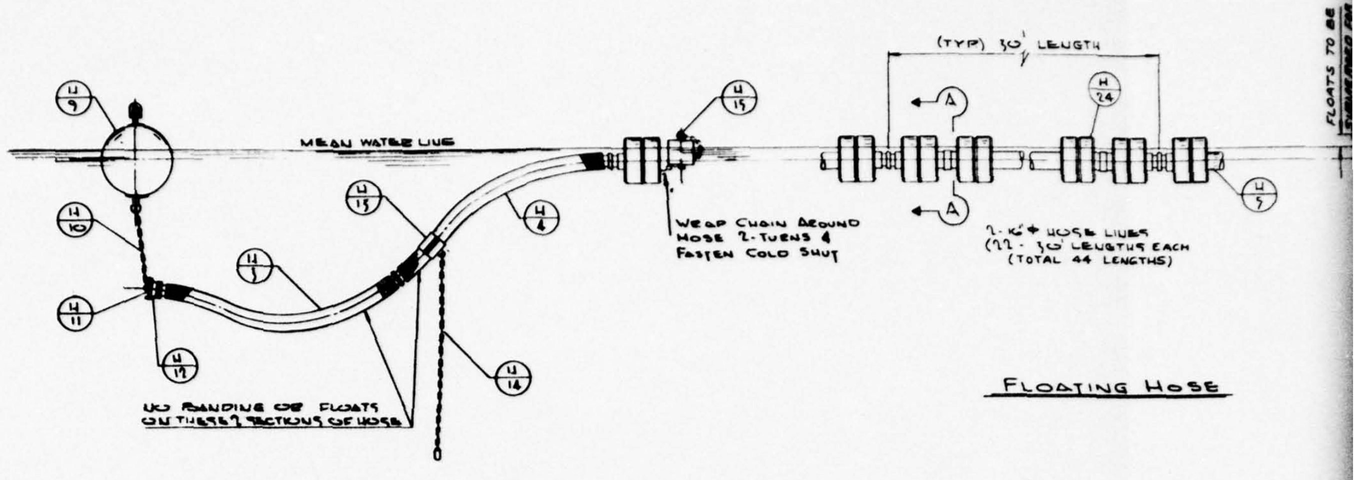
MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

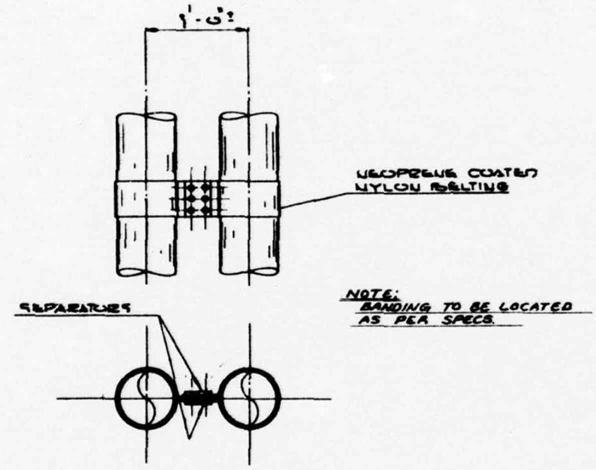
J. RAY McDERMOTT & CO., INC.
ENGINEERS — CONTRACTORS
NEW ORLEANS, LA.

Drawn By	Scale	Date	Project No.
S. Guillory	——	8-24-65	USA 2971
Fabricators Job No.		J. Ray McDermott Job No.	Sheet No.
	56017		827

MOORING SYSTEM



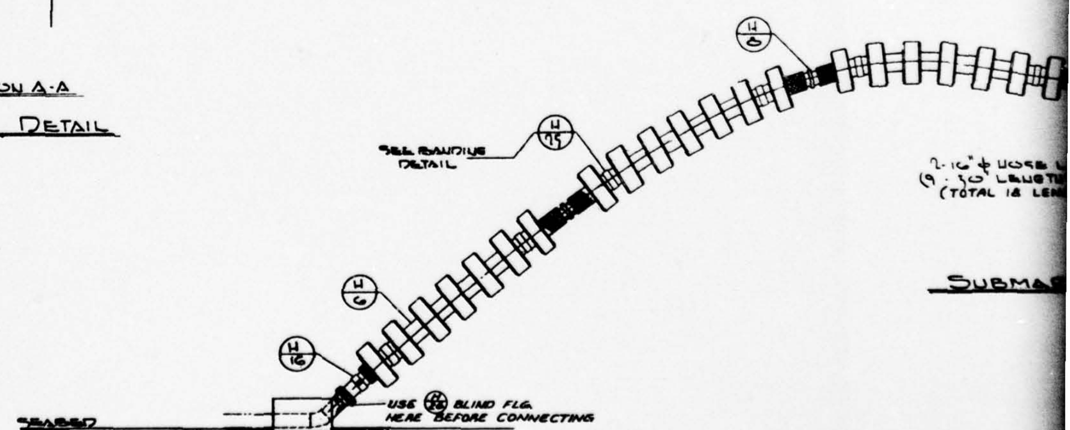
FLOATING HOSE



NOTE: BANDING TO BE LOCATED AS PER SPECS.

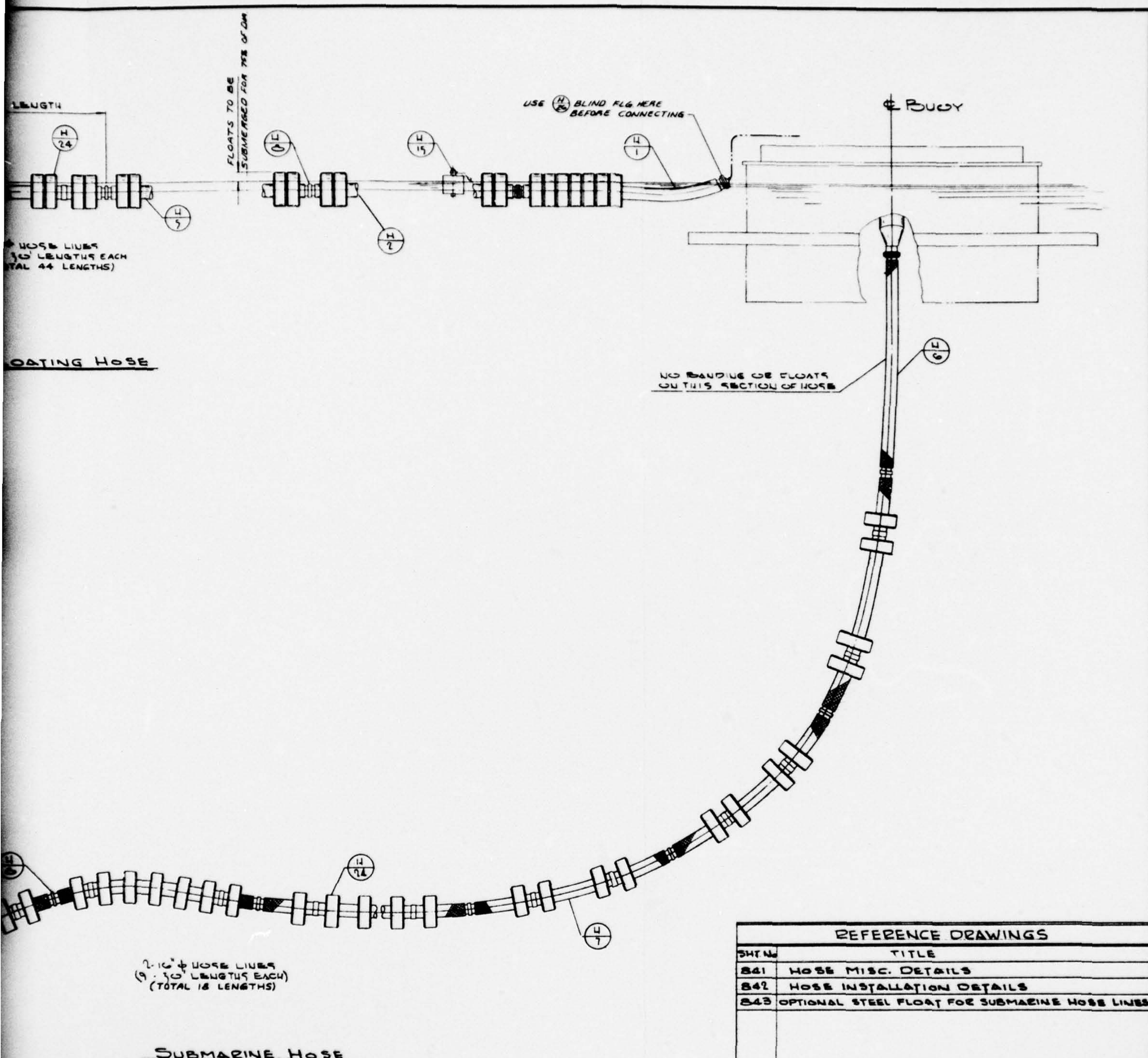
SECTION A-A

BANDING DETAIL



SUBMAR

DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.



REFERENCE DRAWINGS

SHT. No	TITLE
841	HOSE MISC. DETAILS
842	HOSE INSTALLATION DETAILS
843	OPTIONAL STEEL FLOAT FOR SUBMARINE HOSE LINES

EVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 780
REGISTERED PROFESSIONAL ENGINEER IN CIVIL ENGINEERING

APPROVED: G C Lee
J. RAY McDERMOTT & CO., INC.
DATE: 2-18-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT		2-18-66
STRUCTURAL		2-18-66
PROCESS		
MECHANICAL		
ELECTRICAL		
INSTRUMENT		
FAB. CHECK		2-18-66
PROP. CHECK		

MONO-MOORING SYSTEM

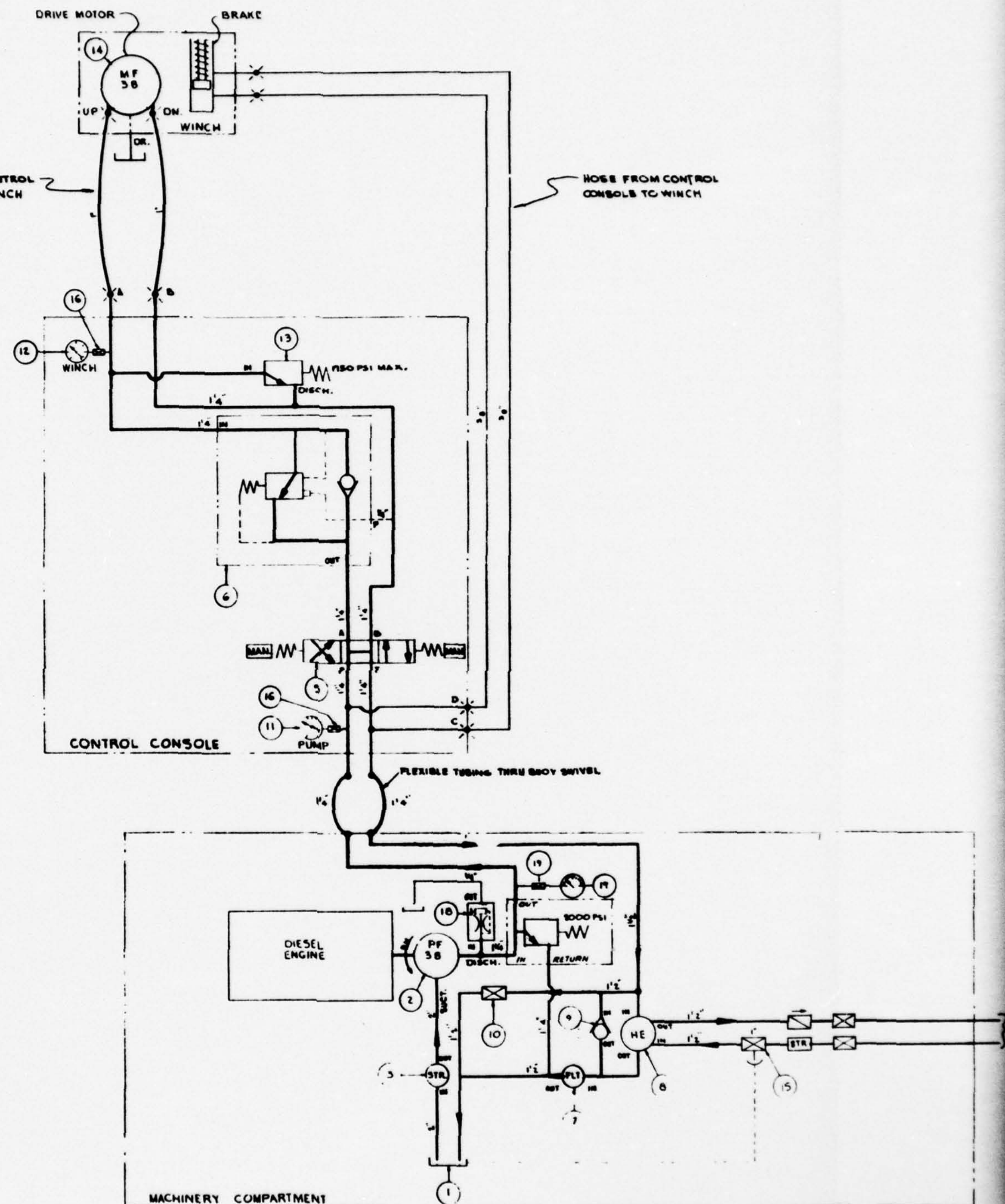
FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
ROSS	1/16" = 1'-0"	2-16-66	USA 2971
FABRICATORS JOB NO.	56017	J. RAY McDERMOTT JOB NO.	SHEET NO. 840

HOSE ASSEMBLY

1



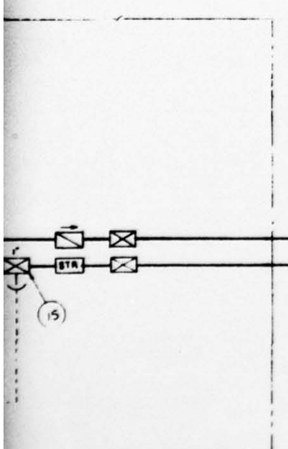
[illegible]	DESIGN	STRUCT.	PIPING	ELEC.	HK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	HK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.

BILL OF MATERIAL

FIND No.	REF DWG No	NOMENCLATURE	SPEC	MAT'L
1	SEE SHT 862	HYDRAULIC OIL RESEVOIR		
2		VICKERS PUMP # 35V30A-1C10-152		
3		VICKERS FILTER # 305-149-M-3-P4		
4		VICKERS BALANCED TYPE RELIEF VA. No CT 10-C-10		
5		VICKERS DIRECTIONAL VALVE # C-1430-C		
6		VICKERS COUNTER BALANCE VALVE # RCG-10-FP1-10 W/SUB &		
7		VICKERS OFM SERIES OIL FILTER OFM 202 1½" PIPE THR'D.		
8		VICKERS COOLER # OCW-4-10 SPECIAL FOR SEA WATER		
9		VICKERS CHECK ANGLE VALVE C2-830-S3		
10		1½ PLUG TYPE ANGLE VALVE VICKERS-DTPA 2-12-10		
11		HELICOID GAGE TYPE #440, SIZE 4½"; FLUSH MTG.; TYP. 316, SOCKET & TIP ASSY.; BACK CONN. ¼" NPT, PHENOL CASE; SC. RAG. 0-3000# PSI		
12		do		
13		VICKERS RELIEF VALVE # CG-10-C-10 W/SUB PLATE		
14		MARINE CONST. & DESIGN CO. MOD. W0960 HYD WINCH		
15		TEMP CONTROL VA. VICKERS MOD. #OCRY-10-B-10 TO OCBW-1-10 SALT WTR.		
16		CRANE ANGLE NEEDLE VALVE # 222H FEMALE ENDS ½"		
17		HELICOID GAGE TYPE #440, SIZE 3½"; TYP. 316, SOCKET & TIP ASSY.; BOTTOM CONN. ¼" NPT PHENOL CASE; SC. RAG. 0-3000# PSI.		
18		VICKERS AIR RELEASE VALVE # ABT-02-10		
19		CRANE ANGLE NEEDLE VALVE # 222H FEMALE ENDS ¼"		

REFERENCE DRAWINGS

SHT. No	TITLE
862	BUOY WINCH HYD. SYSTEM ISOMETRIC



NOTE:
1. FOR PIPING ARRANGEMENT OF SYSTEM SEE ISOMETRIC ON SHEET 862
2. ALL PIPING SHALL BE TO STANDARD J.I.C. PRACTICES.

REVISIONS	DATE	APP	DESIGN	STRUCT.	PIPING	ELEC.		BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 786
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: G C Lee

DATE: 1-28-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT	GCS	1-27-66
STRUCTURAL		
PROCESS		
MECHANICAL	[illegible]	[illegible]
ELECTRICAL		
INSTRUMENT.		
FAB. ORDER	[illegible]	[illegible]
PROP. ORDER		

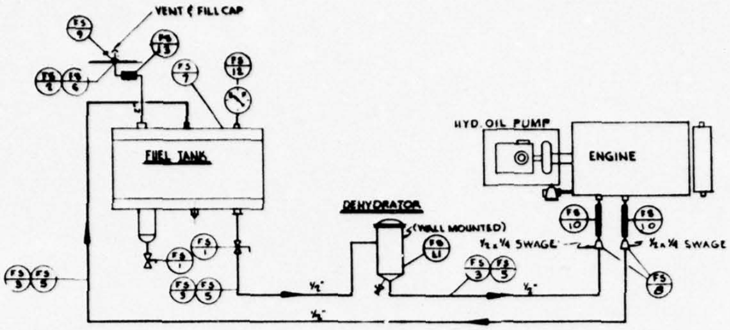
MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

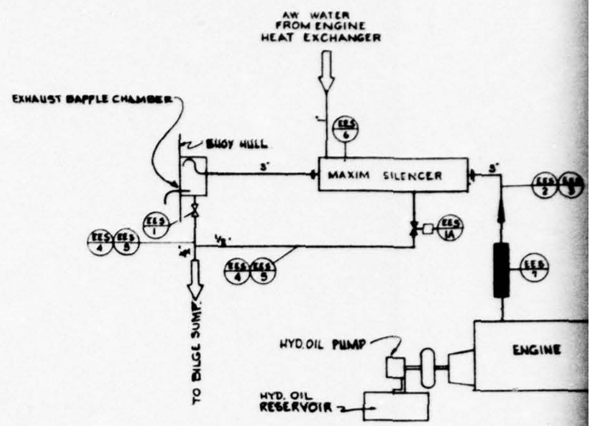
J. RAY McDERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	DWG. NO.
M. GROVES	NONE	11-12-65	USA-2971
	56017		SHEET NO. 861

BUOY WINCH-HYD. SYSTEM SCHEMATIC

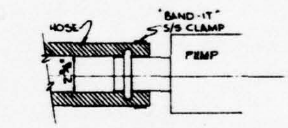


FUEL OIL SCHEMATIC



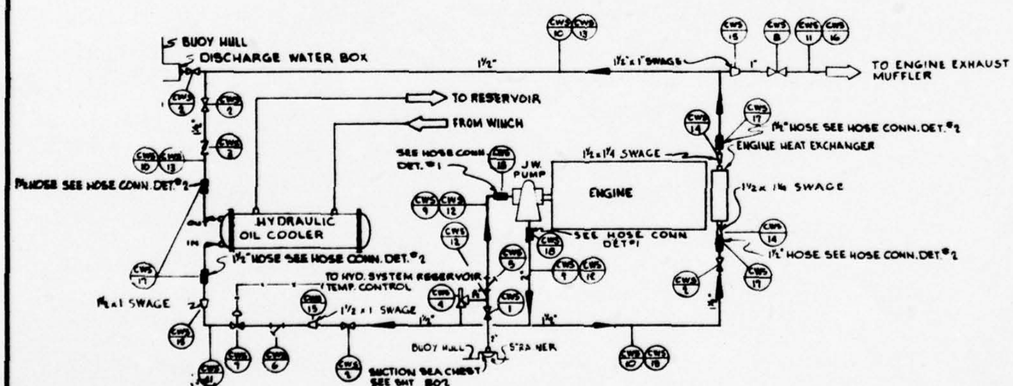
DIESEL ENGINE EXHAUST SCHEMATIC

BILGE PIPING SCHEMATIC

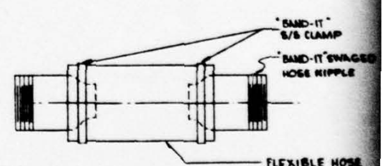


HOSE CONNECTION DETAIL #1

SCALE: NONE



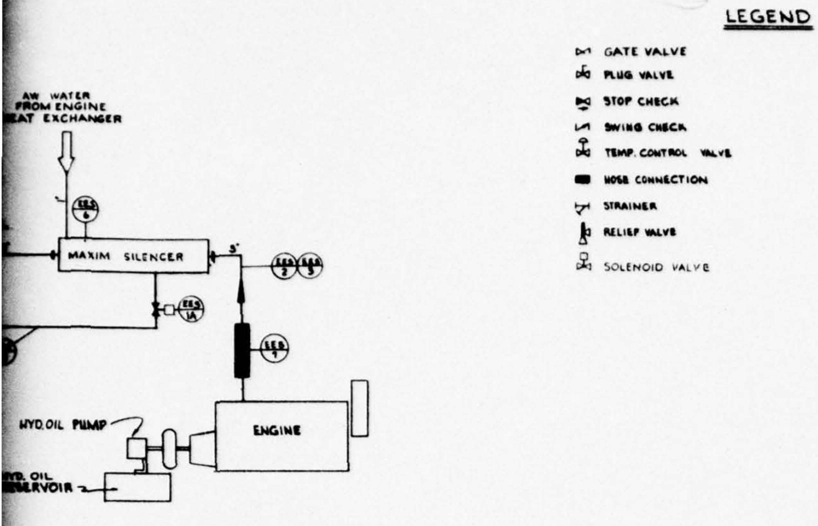
HEAT EXCHANGER RAW WATER SCHEMATIC



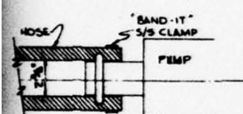
HOSE CONNECTION DETAIL #2

SCALE: NONE

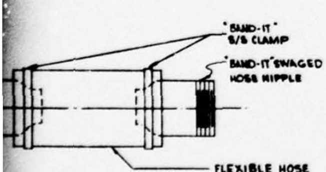
DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN



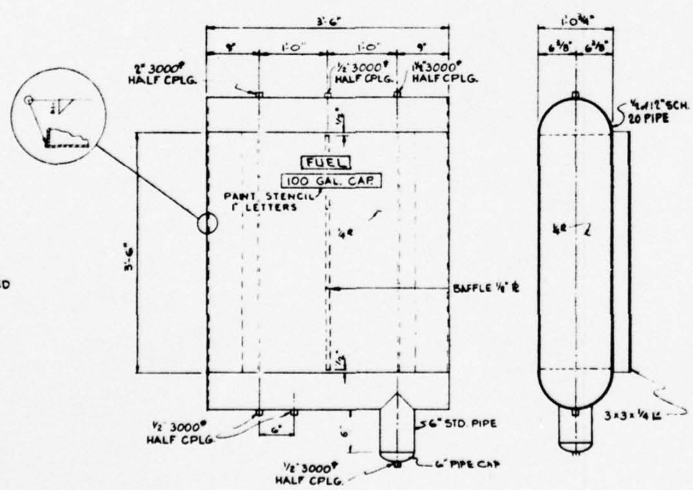
EL ENGINE EXHAUST SCHEMATIC



OSE CONNECTION DETAIL #1
SCALE: NONE



OSE CONNECTION DETAIL #2
SCALE: NONE



FUEL TANK DETAIL
SCALE: 1"=1'-0"

BILL OF MATERIAL

FIND Nº	DWG. Nº	QTY.	NOMENCLATURE	SPEC.	MAT'L.
FS-1	868	2	1/2"-150# SCR'D. PLUG COCK POWELL FIG. 988 OR EQUAL		BRONZE
FS-2		3 LN.FT.	2" STD. SMLS. BLACK PIPE A53-B		A-53-B
FS-3		22 LN.FT.	1/2" STD. SMLS BLACK PIPE A53-B		A53-B
			SCR'D PIPE FITTINGS		FORGED STEEL
FS-4		2 2	1/4"-2000# 90° ELBOW 1/4"-3000# GRD JT UNION		
FS-5		13 2 1	1/2"-2000# 90° ELBOW 1/2"-3000# GRD JT. UNION 1/2"-2000# SQ. HD. PLUG		FORGED STEEL
FS-6		2 1	2"-2000# 90° ELBOW 2"-3000# COUPLING		FORGED STEEL
FS-7		1	FUEL TANK		STEEL
FS-8		2	1/2" x 1/4" STD. SWAGE T.B.E.		A53-B
FS-9	SEE DWG. 897		VENT FILL CAP		———
FS-10	868	2	FLEXIBLE CONNECTION ANACONDA FLEXPIPE #1/4 MIO		BRONZE
FS-11		1	FUEL DEHYDRATOR ROL-PAK #PD-1001WK 1/2"		
FS-12		1	FUEL GAUGE (DIESEL) BOSTON AUTO GAUGE CO. MODEL 114 FOR 54" DEEP TANK		
FS-13		1	HOSE ASSEMBLY: 2" I.D. x 12 1/2" LG, 4 PLY NEO. HOSE 2, #E808 BAND-IT SWAGED HOSE NIP. 2, 5/8 W/BAND-IT CLAMPING BANDS W/SCRD-LOKT BUCKLES TP 316 S.S.		
EES-1		1	1/2-200# SCR'D GATE VALVE POWELL FIG. NO. 375 OR EQUAL		BRONZE
EES-1A		1	ASCO 1/2" SOLENOID VALVE WP-8276 A-19, 24 V DC., N.O.		BRONZE
EES-2		1 LF.	3" STD. SMLS. PIPE		GALV. A53-B
EES-3		1	3"-150#, 90° SCRD. ELBOW		GALV. MALL. IRON
EES-4		14 L.F.	1/2" STD. SMLS. PIPE		GALV. A53-B
EES-5		 5 1 1	150# SCRD. PIPE FITTINGS 1/2" 90° ELBOW 1/2" BRASS SEAT GRD. JT. UNION 1/2" TEE		GALV. MALL. IRON
EES-6		1	EXHAUST SILENCER MAXIM MODEL MB-#6		
EES-7		1	FLEXIBLE EXHAUST CONN. ANACONDA BD-13 HOSE W/PM15 END CONNECTIONS, 2'-11 1/2" OVER ALL LENGTH.		GALV. STEEL
BS-1		2	3/4"-200# SCRD STOP CHECK V. POWELL FIG. 134 OR EQUAL		BRONZE
BS-2		16 L.F.	3/4" STD. SMLS. PIPE		GALV. A53-B
BS-3		 4 2	150# SCRD. PIPE FITTINGS 3/4" 90° ELBOW 3/4" BRASS SEAT GRD. JT. UNIONS		GALV. MALL. IRON
BS-4		2	3/4" x 1/2" 3/80 SWAGE T.B.E.		GALV. A53-B
BS-5		ASSORT'D	1/2" & 3/4" STD. PIPE NIPPLES		GALV. A53-B
BS-6		2	BILGE PUMP SUTTON MFG. CORP. MODEL NO. FSA-24 (24V. D.C.)		BRONZE

— B/M CONTINUED ON SHEET 869 —

REFERENCE DRAWINGS

SHT. NO.	TITLE
869	DIESEL ENGINE PIPING ARRANGEMENT
861	HYDRAULIC SYSTEM SCHEMATIC
862	HYDRAULIC SYSTEM ISOMETRIC

REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 708
CIVIL ENGINEERING

APPROVED: G C Lee
J. RAY McDERMOTT & CO., INC.
DATE 1-28-66
ENGINEERS APPROVAL

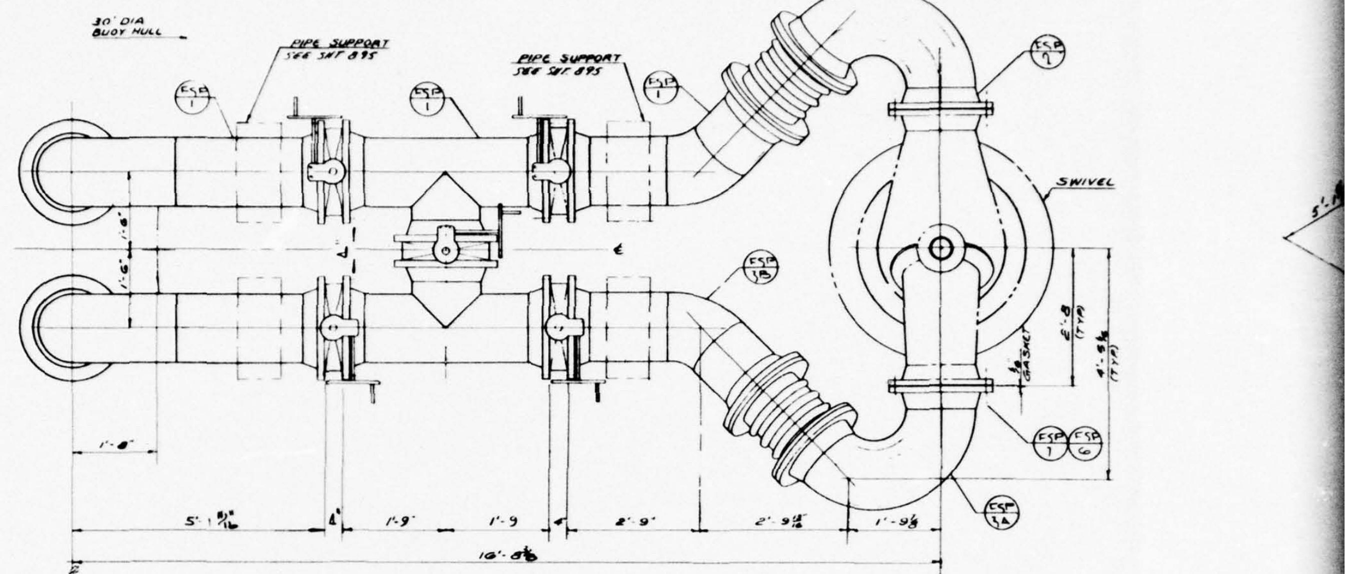
MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

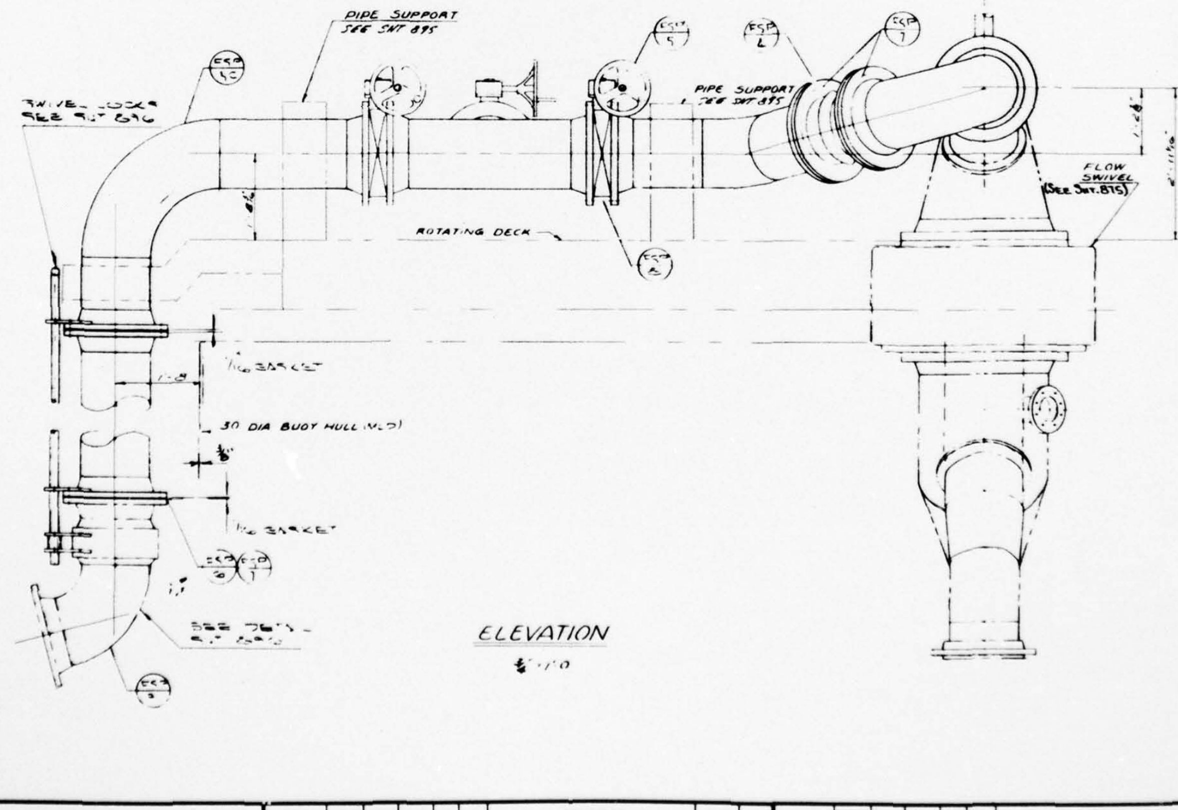
DRAWN BY	SCALE	DATE	PROJECT NO.
Robert J. Rohde		8-19-65	U.S.A. 5771
FABRICATORS JOB NO.	56017	J. RAY McDERMOTT JOB NO.	SHEET NO. 868

DIESEL ENGINE PIPING SCHEMATICS



PLAN

¼" = 1'-0



ELEVATION

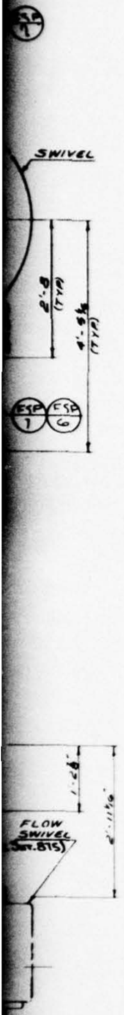
¼" = 1'-0

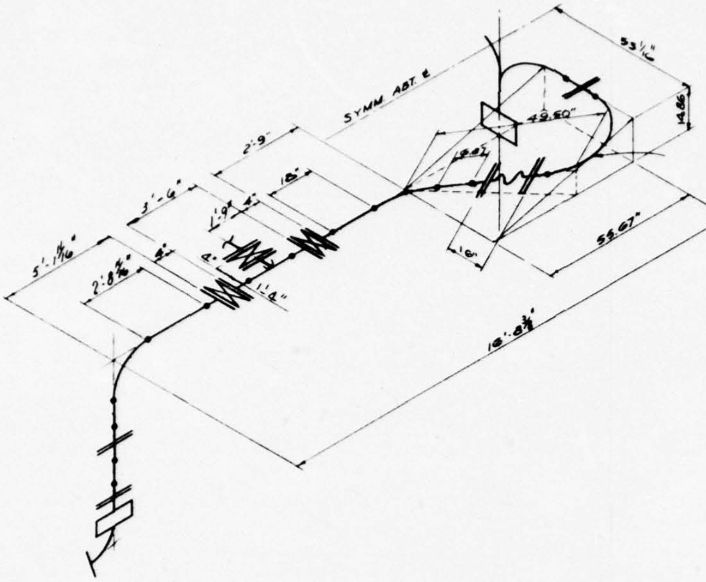
DESIGN	STRUCT.	PIPING	ELEC	MK	BY	REVISIONS	DATE	APP	DESIGN	STRUCT	PIPING	ELEC	MK	BY	REVISIONS	DATE	APP	DESIGN	STRUCT.

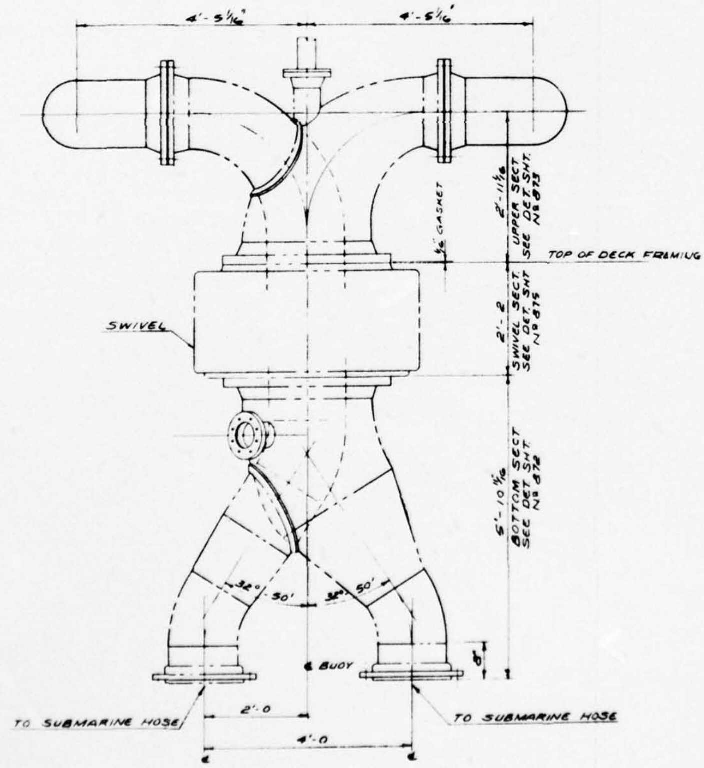
2

BILL OF MATERIAL

FIND No	DWG No	QTY	NOMENCLATURE	SPEC	MAT'L
FSP-1	870	20'	16" STD. PIPE		A106-B
FSP-2	do	22	16" 150# FF. W.N. FLG		A181-1
FSP 3-A	do	2	16" STD 180° R.B. RET. BEND CUT TO 135°		A234-WPB
FSP 3-B	do	2	16" STD. LR. 45° ELL		do
FSP 3-C	do	2	16" STD LR. 90° ELL		do
FSP 4	do	2	16" EXPANSION JT. 200 PSIG RATED, MULTI ARCH CONST. W/CONTL ROD UNIT 16" F/F DIM.		BUNA N INNER TUBE & NEOPRENE OUTER JACKET
FSP 5	do	5	16" BUTTERFLY VALVE BUNA-N SEAT, 316 S.S. DISC, STEM, UPPER & LOWER BUSHING, WEATHER PROOF GEAR OPERATOR 30:1 KEYSTONE STYLE 100		CARBON STL.
FSP 6	do	6	1/16" GASKET FULL FACE		ASBESTOS
FSP 7	do	160	STUD BOLT W/HEX NUTS 1"-8-NC x 5 1/4"		A193-B6 A194-B6
FSP 8	do	80	STUD BOLT W/HEX NUTS 1"-8-NC-9" (7 1/2 THD BOTH ENDS)		do
FSP 9	896	—	SWIVEL ELBOW CONN.		







ELEVATION
3/4" = 1'-0

REFERENCE DRAWINGS

SHT. No	TITLE
871	FLOW SWIVEL UNIT ASSEMBLY
872	FLOW SWIVEL LOWER UNIT - DETAILS
873	FLOW SWIVEL UPPER UNIT - DETAILS
895	FLOW SYSTEM PIPE SUPPORTS
896	SWIVEL LOCKS FLOW SYSTEM PIPING
875	FLOW SWIVEL ASSEMBLY

NOTE:
ASSEMBLE ALL BOLTING WITH AN ANTI-SEIZING THREAD COMPOUND.

REVISIONS	DATE	APP	DESIGN	STRUCT	PIPING	ELEC	MK	BY	REVISIONS	DATE	APP

STATE OF LOUISIANA — GRIFF C. LEE — REG. No. 786 — REGISTERED PROFESSIONAL ENGINEER IN CIVIL ENGINEERING

APPROVED G.C. Lee
J. RAY McDERMOTT & CO. INC
DATE 1-28-66

ENGINEERS APPROVAL	BY	DATE
PROJECT		1-27-66
STRUCTURAL		
PROCESS		
MECHANICAL		9/17
ELECTRICAL		
INSTRUMENT		
FAB CHECK		9/17
PROOF CHECK		

MONO-MOORING SYSTEM

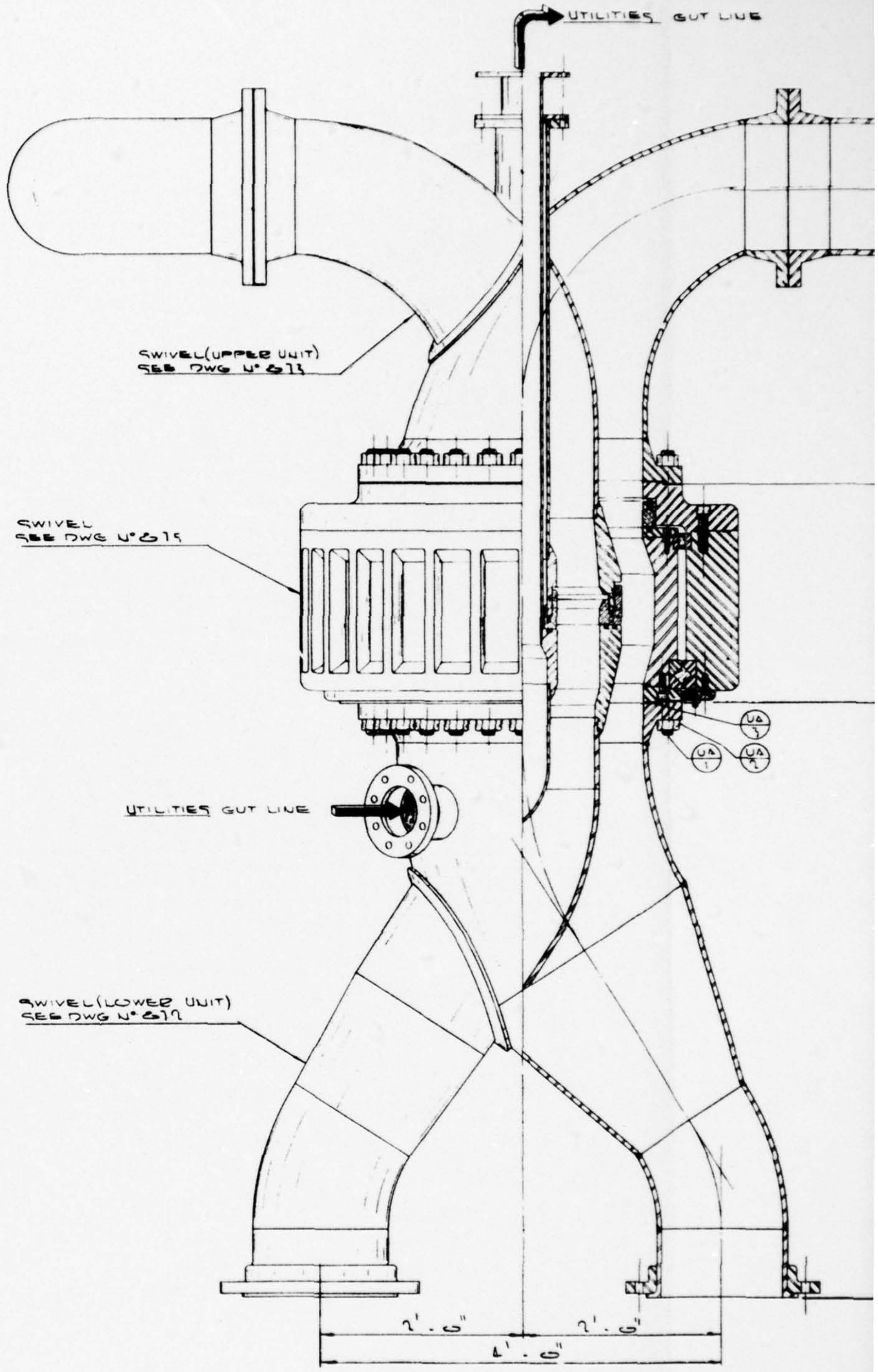
FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS — CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
FRANCHINA	NOTED	6-14-65	USA-2971

FABRICATORS JOB NO.	J. RAY McDERMOTT JOB NO.	SHEET NO.
56017		870

FLOW SYSTEM PIPING ARRANGEMENT



FLOW SWIVEL ASSEMBLY

SCALE: 1½" = 1'-0"

	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PI

AD-A034 248 MCDERMOTT (J RAY) CO INC NEW ORLEANS LA F/G 13/10

ENGINEER DESIGN OF A MONO-MOORING SYSTEM.(U)

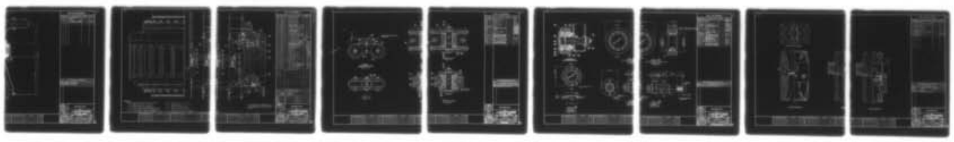
1966 DA-44-009-AMC-841(T)

UNCLASSIFIED NL

3 OF 3

AD

A034248

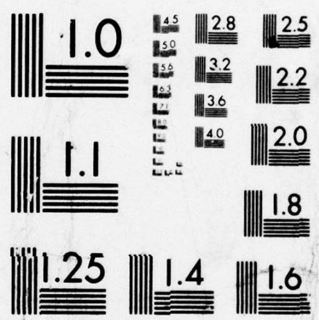


END

DATE

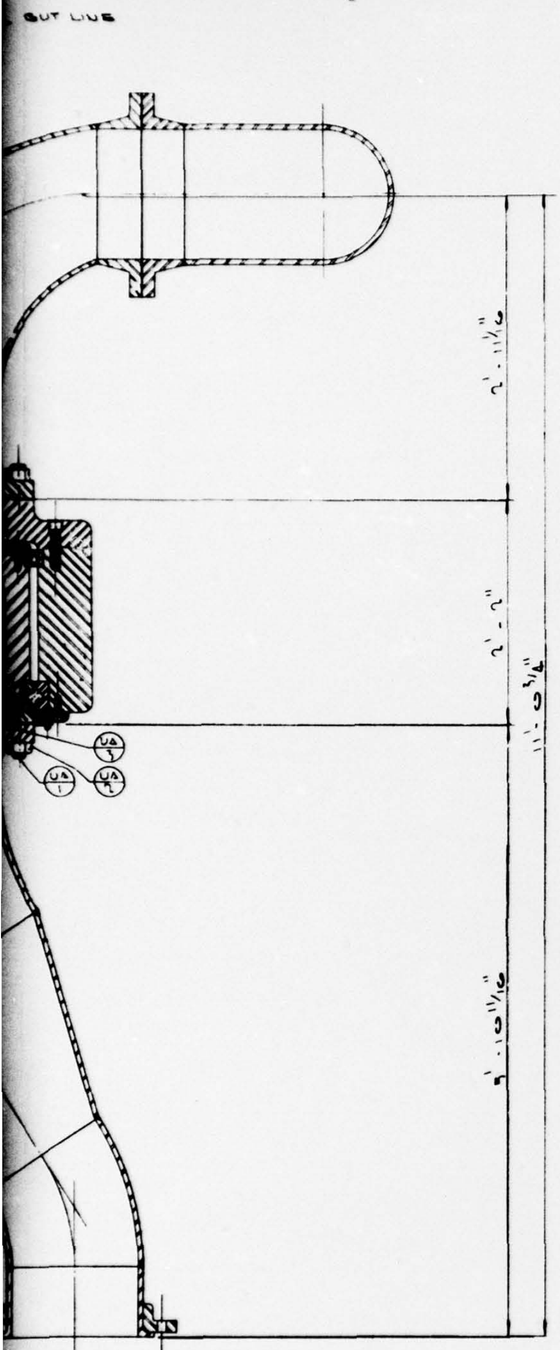
FILMED

2-77



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2



BILL OF MATERIAL

FIND Nº	DWG Nº	QTY	NOMENCLATURE	SPEC	MAT'L
UA-1	671	56	1 1/4 - 8UN x 6 1/2 SS STUDS		
UA-2	671	56	1 1/4 - 8UN		
UA-3	671	2	33 1/8 OD x 29 I.D. GRAPH. IMPREGNATED ASB. GASK		ASBESTOS

REFERENCE DRAWINGS

SHT. NO	
672	LOWER UNIT DETAILS
673	UPPER UNIT DETAILS
675	SWIVEL ASSEMBLY

	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 705
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: GCLee
J. RAY McDERMOTT & CO., INC.
DATE: 1-27-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT	JBS	1-27-66
STRUCTURAL		
PROCESS		
MECHANICAL		9/17
ELECTRICAL		
INSTRUMENT		
FAB. CHECK		9/17
PROP. CHECK		

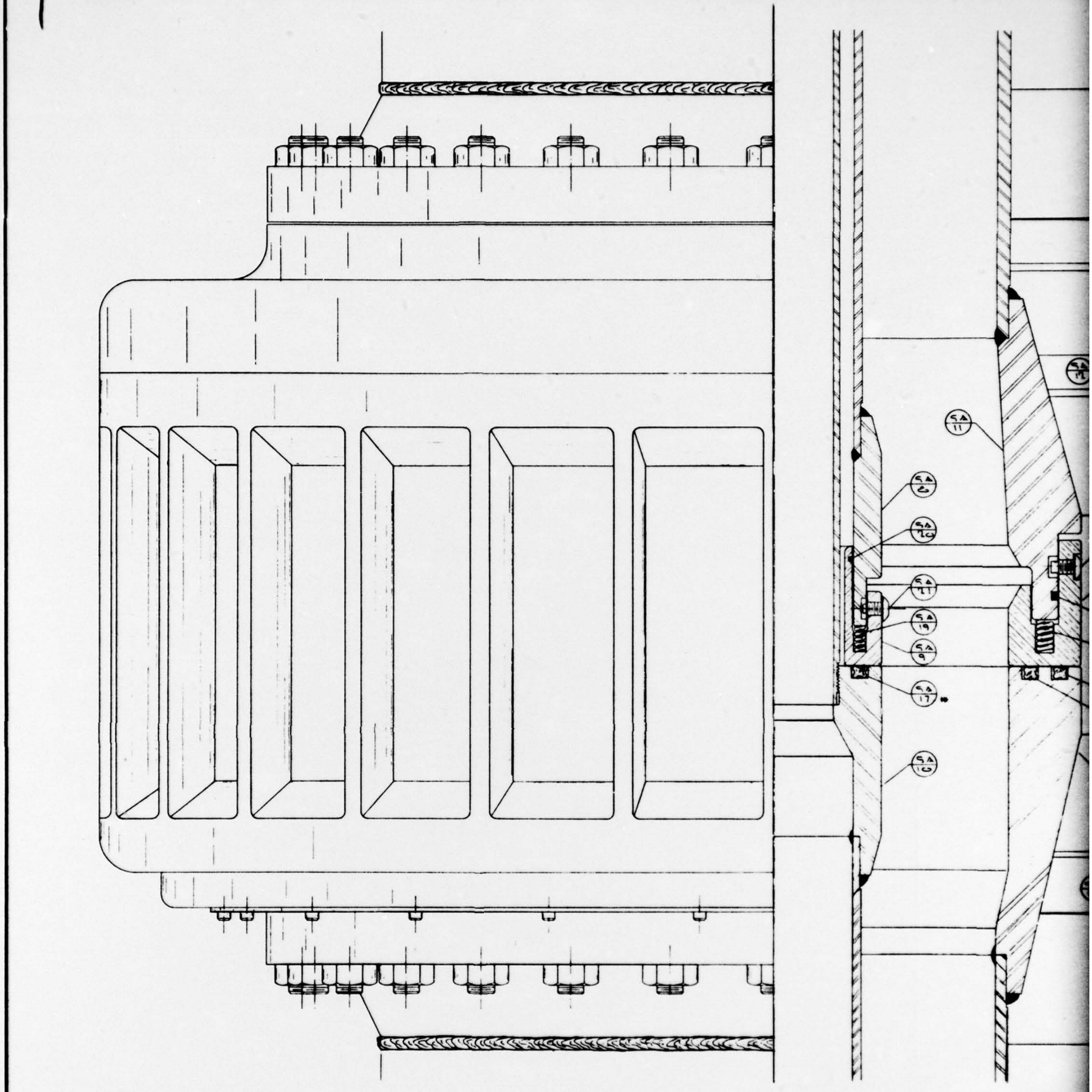
MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH
& DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY Mc DERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
ROSS	NOTED	6-16-65	USA-2971
FABRICATORS JOB NO.	96617	J. RAY McDERMOTT JOB NO.	SHEET NO. 671

FLOW UNIT SWIVEL ASSEMBLY



NOTES

SA-13 - ARP-568-A-470 21" I.D. x 21½ O.D. x ¼ C.S. BUNA-N COMPOUND 70 DURO. A

SA-20 - ARP-568- 5¾" I.D. x 6" O.D. x ⅛ C.S. BUNA-N COMPOUND 70 DURO. A

SA-23 - MESSINGER ROLLER BEARING 30.7471 I.D. x 41.0002 O.D. x 1.675" WIDE (REF DWG. 23655-1)

SA-24 - MESSINGER (X TYPE) ROLLER BEARING 35.496 I.D. x 42.255" O.D. x 3.375" WIDE (REF DWG. 23655-1)

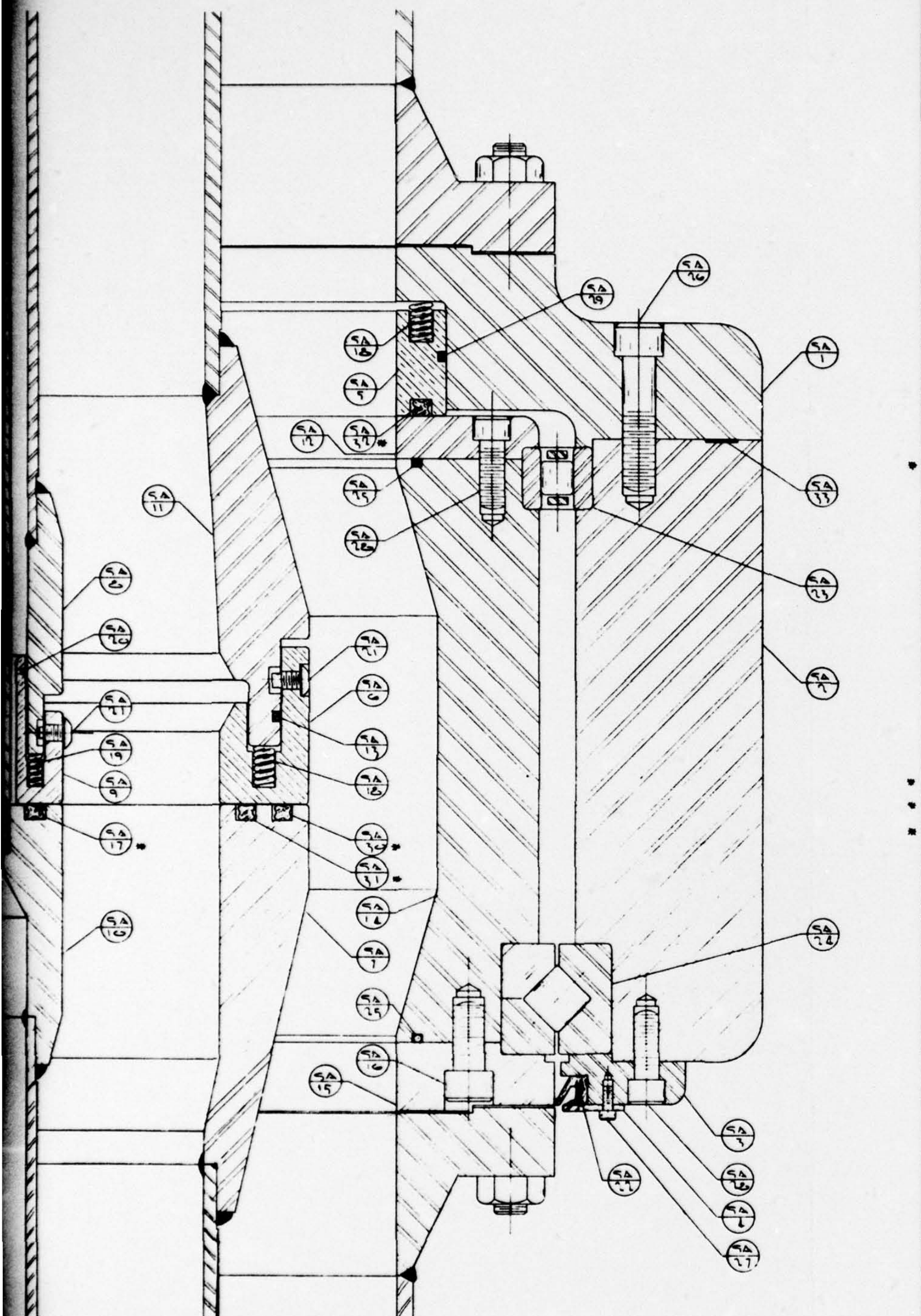
SA-25 - 30" I.D. x 30½ O.D. x ¼ C.S. BUNA N 70 DURO A

SA-22 - GARLOCK SEAL # 23x9641 (35¼ I.D. x 40¼ O.D. x [illegible])

SA-29 - 31½" I.D. x 32" O.D. x ¼ C.S. BUNA N COMPOUND 70 DURO A

SA-33 GASKET COMPOUND NATIONAL ENGR. PRODUCTS INC. COPALTITE CEMENT

DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING



BILL OF MATERIAL

	FIND Nº	DWG. Nº	QTY	NOMENCLATURE	SPEC.	MAT'L
	SA-1	876	1	BEARING CAP		
	SA-2	877	1	MAIN HOUSING		
	SA-3	878	1	SEAL HOUSING		
	SA-4	878	1	SEAL RETAINER		
	SA-5	879	1	SEAL SLEEVE		
	SA-6	882	1	INTERMEDIATE FLOATING SEAL SLEEVE		
	SA-7	880	1	INTERMEDIATE SEAL RING		
	SA-8	881	1	INNER SEAL TONGUE		
	SA-9	881	1	INNER FLOATING SEAL SLEEVE		
	SA-10	881	1	INNER SEAT RING		
	SA-11	880	1	INTERMEDIATE SEAL TONGUE		
	SA-12	876	1	TOP BEARING RETAINER		
	SA-13	875	1	SEE NOTE SA-13		BUNA N
	SA-14	877	1	INNER HOUSING		
	SA-15	879	1	LOWER BEARING RETAINER		
	SA-16	875	28	1" 8NC x 2" SOCK. HD CAP SCREWS		STEEL
*	SA-17	875	1	QUAD RING MINNESOTA RUBBER CO. PART # 651947		BUNA N
	SA-18	875	64	DANLY DIE SPRING # 9-1206-21		STEEL
	SA-19	875	16	DANLY DIE SPRING # 9-0809-31		STEEL
	SA-20	875	1	SEE NOTE SA-20		BUNA N
	SA-21	882	7	KEEPER		STEEL
	SA-22	875	1	SEE NOTE SA-22		RUBBER
	SA-23	875	1	SEE NOTE SA-23		STEEL
	SA-24	875	1	SEE NOTE SA-24		STEEL
	SA-25	875	2	SEE NOTE SA-25		BUNA N
	SA-26	875	28	1"-8NC x 4" SOCK. HD CAP SCRW		S.S.
	SA-27	875	22	5/16-18 NC x 1/2 do		S.S.
	SA-28	875	56	3/4-10 NC x 2" do		S.S.
	SA-29	875	1	SEE NOTE SA-29		BUNA N
*	SA-30	875	1	QUAD RING MINN. RUBBER PART # 651962		BUNA N
*	SA-31	875	1	QUAD RING # 651961		BUNA N
*	SA-32	875	1	QUAD RING # 651950		BUNA N
	SA-33	875	1/2 LB	SEE NOTE SA-33		
	SA-34					
	SA-35					
	SA-36					

REFERENCE DRAWING

SHT Nº	TITLE
871	FLOW UNIT SWIVEL ASSEMBLY
872	LOWER UNIT DETAILS
873	UPPER UNIT DETAILS
876	FLOW SWIVEL DETAILS SHT. 1
877	do SHT. 2
878	do SHT. 3
879	do SHT. 4
880	do SHT. 5
881	do SHT. 6
882	do SHT. 7

* THESE SEAL RINGS ARE DESIGNS MANUFACTURED BY MINNESOTA RUBBER CO., MINNEAPOLIS MINN. & SHALL BE TO THEIR COMPOUND # 431 T & (X SEL) TREATED

REVISIONS	DATE	APP	DESIGN	STRUCT	PIPING	ELEC	NK	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 786
REGISTERED
PROFESSIONAL ENGINEER

APPROVED G.C. Lee
J. RAY McDERMOTT & CO. INC.
DATE 1-28-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT		
STRUCTURAL		
PROCESS		
MECHANICAL		8/17
ELECTRICAL		
INSTRUMENT		
FAB. CHECK		
PROP. CHECK		

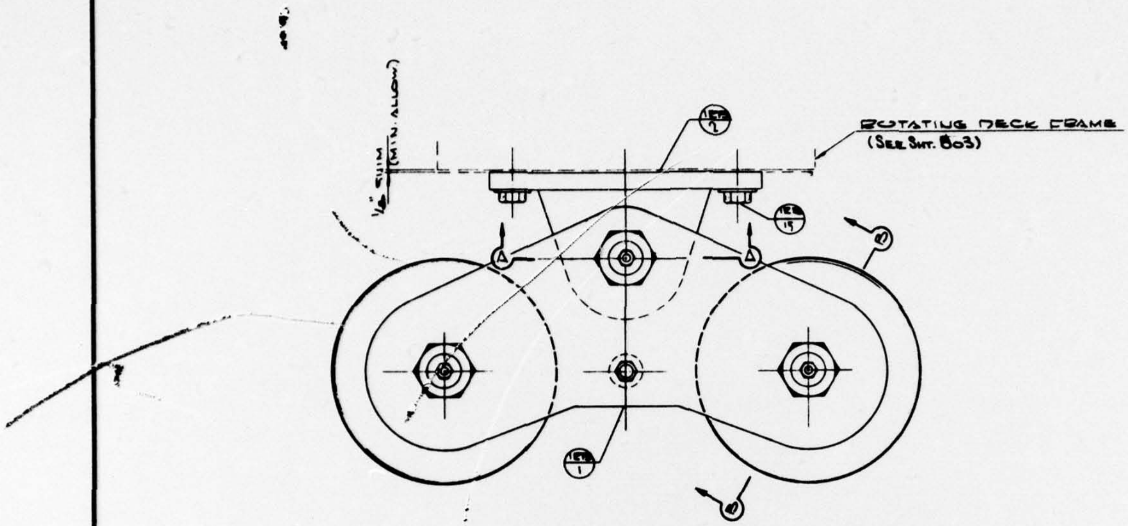
MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH
& DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

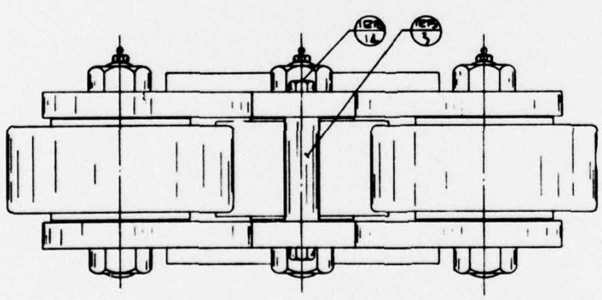
J. RAY Mc DERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
ROSS	HALF	7-1-65	USA-2971
FABRICATORS JOB NO.	56017	J. RAY McDERMOTT JOB NO.	SHEET NO. 875

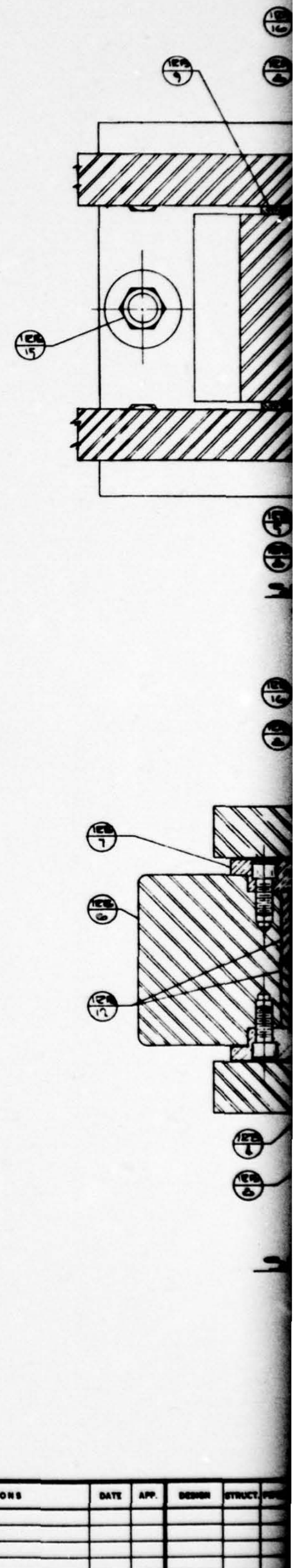
FLOW SWIVEL ASSEMBLY



PLAN
INNER RACE BOGIE
SCALE: 3"=1'-0"



ELEVATION
SCALE: 3"=1'-0"



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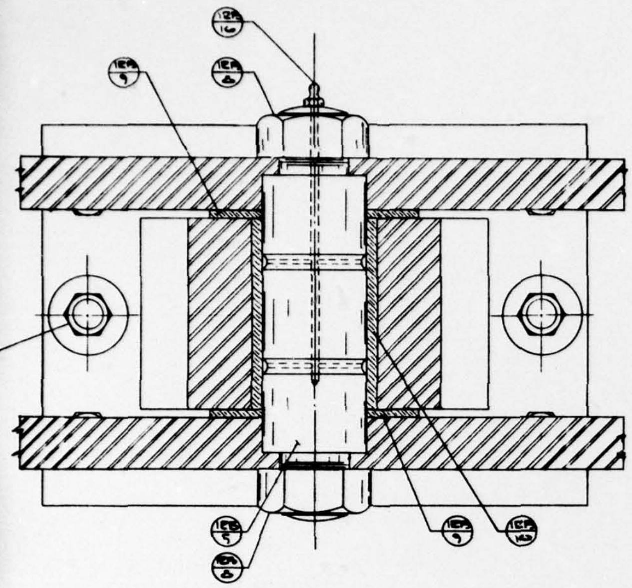
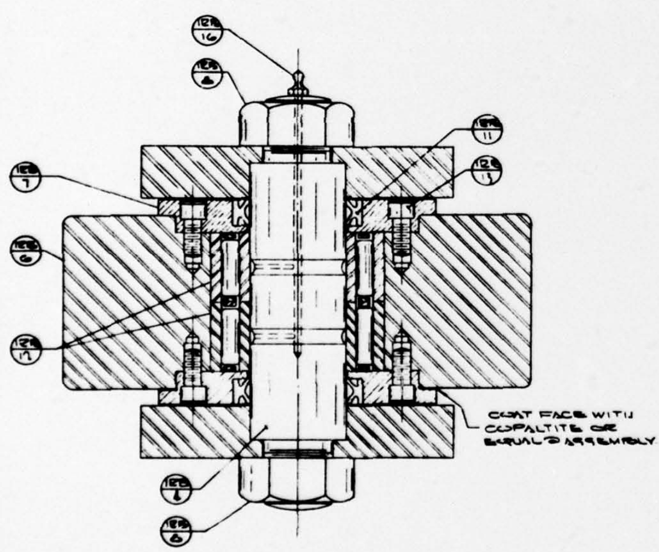


SECTION A-A

SCALE: HALF



SECTION B-B

SCALE: HALF

BILL OF MATERIAL

FIND No.	DWG No.	QTY	NOMENCLATURE	SPEC.	MAT'L.
12B-1	SEE SHT. [illegible]		BOGIE YOKE		H.R.S.
12B-2	do		BOGIE CLEVIS		H.R.S.
12B-3	do		SPACER		C.R.S.
12B-4	do		WHEEL AXLE		316 MO S. STL.
12B-5	do		CLEVIS AXLE		316 MO S. STL.
12B-6	SEE SHT. [illegible]		WHEEL		CARB. STL. [illegible]
12B-7	do		BEARING RETAINER & SEAL R		[illegible] SAE #660
12B-8	do		NUT		ALU. BRZ. [illegible]
12B-9	do		THRUST WASHER		[illegible] SAE #660
12B-10	do		BEARING		[illegible] SAE 660
12B-11	883	24	GARLOCK #[illegible] (STAINLESS [illegible]		
12B-12	do	24	AMERICAN ROLLER REG. #HCS-[illegible] LUB.		
12B-13	do	192	1/2-13 UC. x 1 1/2 SOCK HD. 316 S/S		STAINLESS
12B-14	do	12	7/16-9-NC x 2 1/2 HEX. HD.-316 S/S		do
12B-15	do	24	7/16-9-NC x 3 1/2 [illegible] W/NUTS & WASHERS 316 S/S		do
12B-16	do	18	GREASE FITTING W/ [illegible] LINCOLN #5000 OR EQ.		

REFERENCE DRAWINGS

SHT. No.	TITLE
884	INNER RACE BOGIE WHEELS DETAILS SHT. 1
885	INNER RACE BOGIE WHEELS DETAILS SHT. 2
886	INNER RACE BOGIE WHEEL SUPPORT
803	ROTATING DECK FRAMING PLAN

DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 700
REGISTERED PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: GCLee
J. RAY McDERMOTT & CO., INC.
DATE: 1-28-66

ENGINEERING APPROVAL

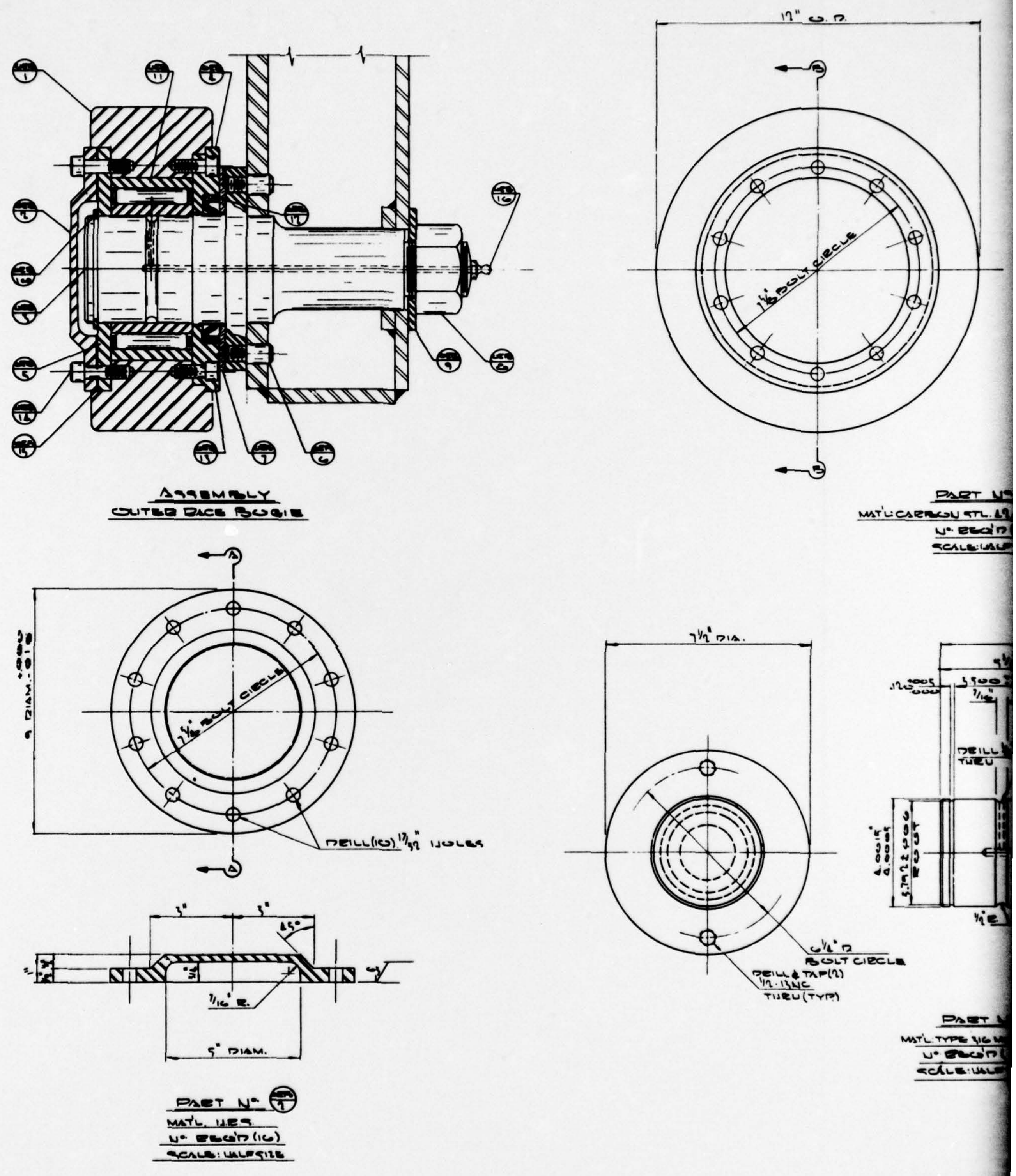
MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH
& DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

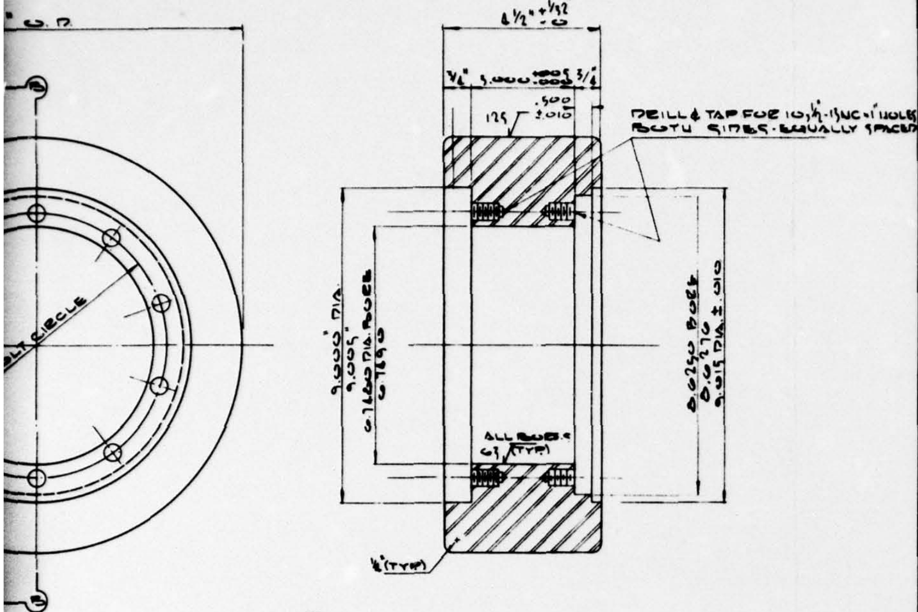
DRAWN BY	SCALE	DATE	PROJECT No.
BOSS	NOTED	5-6-65	USA-2931
FABRICATION JOB No.	96017		SHEET No. 883

ASSEMBLY
INNER RACE BOGIE WHEELS



DESIGN	STRUCT.	PIPING	ELEC.	MR.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MR.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING

2

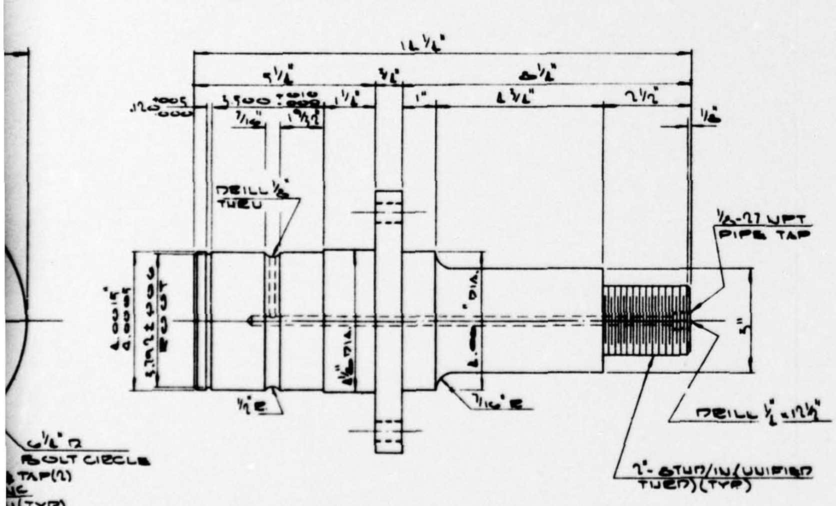


PART N° (1)

MAT'L: CARBON STL. 67,000 MIN. YIELD

N° REQ'D (16)

SCALE: HALF SIZE



PART N° (3)

MAT'L. TYPE 316 MO SS.

N° REQ'D (16)

SCALE: HALF SIZE

BILL OF MATERIAL

FIND N°	DWG N°	QTY.	NOMENCLATURE	SPEC.	MAT'L.
[illegible]-1	885	16	WHEEL		CARB. STL. 67,000 YIELD
[illegible]-2	do	16	CAP		H.R.S.
[illegible]-3	do	16	WHEEL AXLE		316 MO S. STL.
[illegible]-4	SEE SHT. 887		OIL SEAL HOUSING HOUSING & REG. RETAINER		[illegible]
[illegible]-5	do		REG. RETAINER		316 MO S/S
[illegible]-6	do		DOGS		316 MO S/S
[illegible]-7	do		THRUST WASHER		[illegible]
[illegible]-8			SEE IER-8 SHT 885		
[illegible]-9	SEE SHT. 887		WASHER		H.R.S.
[illegible]-10	885	16	TRU-ARC RETAINER RING #5100-600 (PH-15-7-MO)		PH-15-7-MO
[illegible]-11	do	16	AMERICAN ROLLER BRG #HCS-771		
[illegible]-12	do	16	BARLOCK #53X2610 S/S CASE & SPRING		S. STL
[illegible]-13	do	160	1/2-13-NC×1 1/2 SOCK. HD. 316 S/S		S. STL.
[illegible]-14	do	160	1/2-13-NC×1 1/2 LG SOCK. HD 316 S/S		S. STL.
[illegible]-15	do		COPALTITE COATING		GASKET
[illegible]-16	do		GREASE FITTING W/CHECK LINCOLN #5000 OR EQUAL		

REFERENCE DRAWINGS

DWG. N°	TITLE
885	DETAILS OUTER RACE BOGIE WHEELS
603	ROTATING DECK FRAMING PLAN

								REVISIONS	DATE	APP.
DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	CK.	BY			

STATE OF LOUISIANA
GRIFF C. LEE
REG. NO. 705
CIVIL ENGINEERING

APPROVED: G. C. Lee
DATE: 1-28-66

ENGINEERS APPROVAL

MONO-MOORING SYSTEM

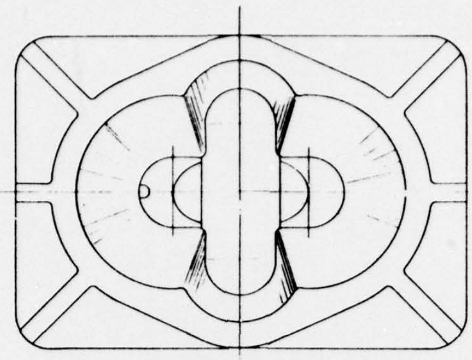
FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY McDERMOTT & CO., INC.
ENGINEERS · CONTRACTORS
NEW ORLEANS, LA.

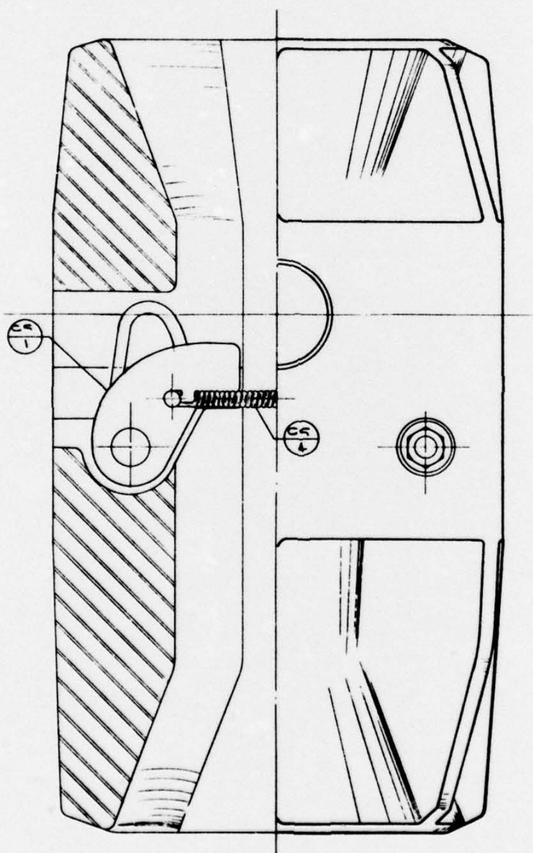
DRAWN BY: ROSS
SCALE: NOTED
DATE: 5-28-65
PROJECT NO.: USA-2971
FABRICATORS JOB NO.: 56017
SHEET NO.: 886

ASSEMBLY & DETAILS OUTER RACE BOGIE WHEELS (SHT. 2)

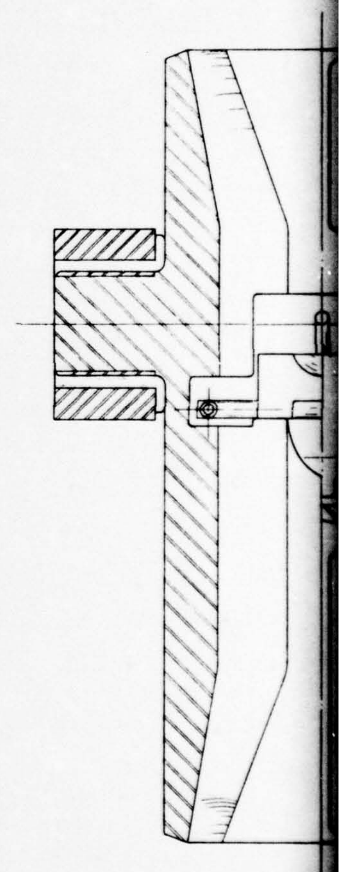
1



TOP & BOTTOM VIEW



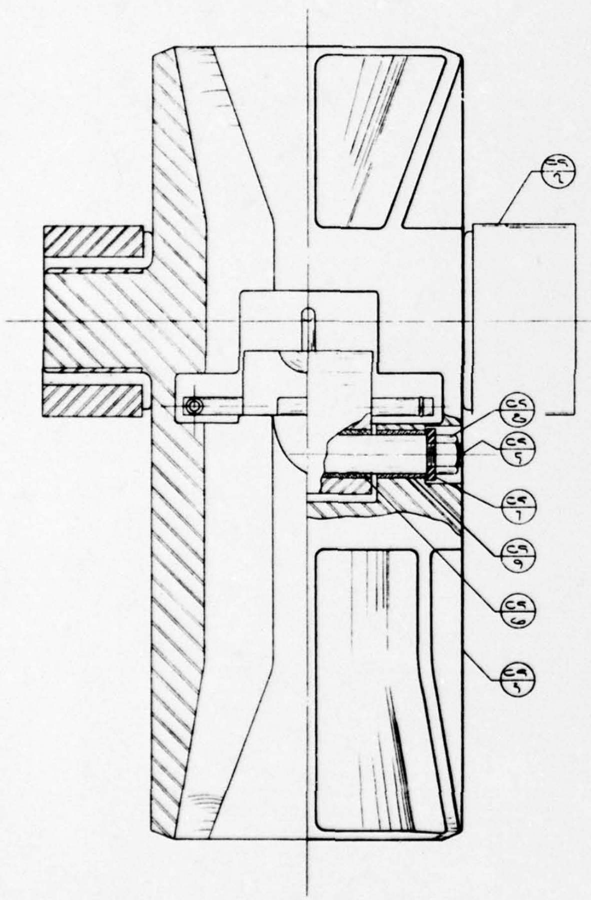
SIDE ELEVATION



FRONT

DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING

2



FRONT ELEVATION

BILL OF MATERIAL

FIND Nº	DWG Nº	QTY.	NOMENCLATURE	SPEC.	MAT'L
CS-1	SEE SHT. 889		PAWL		
CS-2	do		TRUNNION BEARING		
CS-3	SEE SHT. 890		BODY		
CS-4	SHT. SHT. 891		SPRING		
CS-5	do		SHAFT		
CS-6	SEE SHT. 889		BUSHING		
CS-7	SEE SHT. 891		THRUST WASHER		
CS-8	888	16	NUT 1¼-8-NF		SAE 1018 CR.
CS-9	SEE SHT. 890		BUSHING		

REFERENCE DRAWINGS

SHT Nº	TITLE
889	CHAIN STOPPER DETAILS SHT. Nº 1
890	do SHT. Nº 2
891	do SHT. Nº 3
804	MISC DETAILS
801	MACHINERY DECK FRAMING PLAN

REVISIONS	DATE	APP.	DESIGN	STRUCT.	PIPING	ELEC.	MK.	BY	REVISIONS	DATE	APP.

STATE OF LOUISIANA
GRIFF C. LEE
REG. No. 786
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

APPROVED: GCLee
J. RAY McDERMOTT & CO., INC.
DATE: 1-28-66

ENGINEERS APPROVAL

	BY	DATE
PROJECT	GCL	1-28-66
STRUCTURAL		
PROCESS		
MECHANICAL		9/17
ELECTRICAL		
INSTRUMENT		
FAB. CHECK		9/17
PROP. CHECK		

MONO-MOORING SYSTEM

FOR
U.S. ARMY ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

J. RAY Mc DERMOTT & CO., INC.
ENGINEERS CONTRACTORS
NEW ORLEANS, LA.

DRAWN BY	SCALE	DATE	PROJECT NO.
ROSS	3" = 1'-0"	7-30-65	USA-2971
FABRICATORS JOB NO.		J. RAY McDERMOTT JOB NO.	SHEET NO.
	60017		888

ASSEMBLY-CHAIN STOPPER